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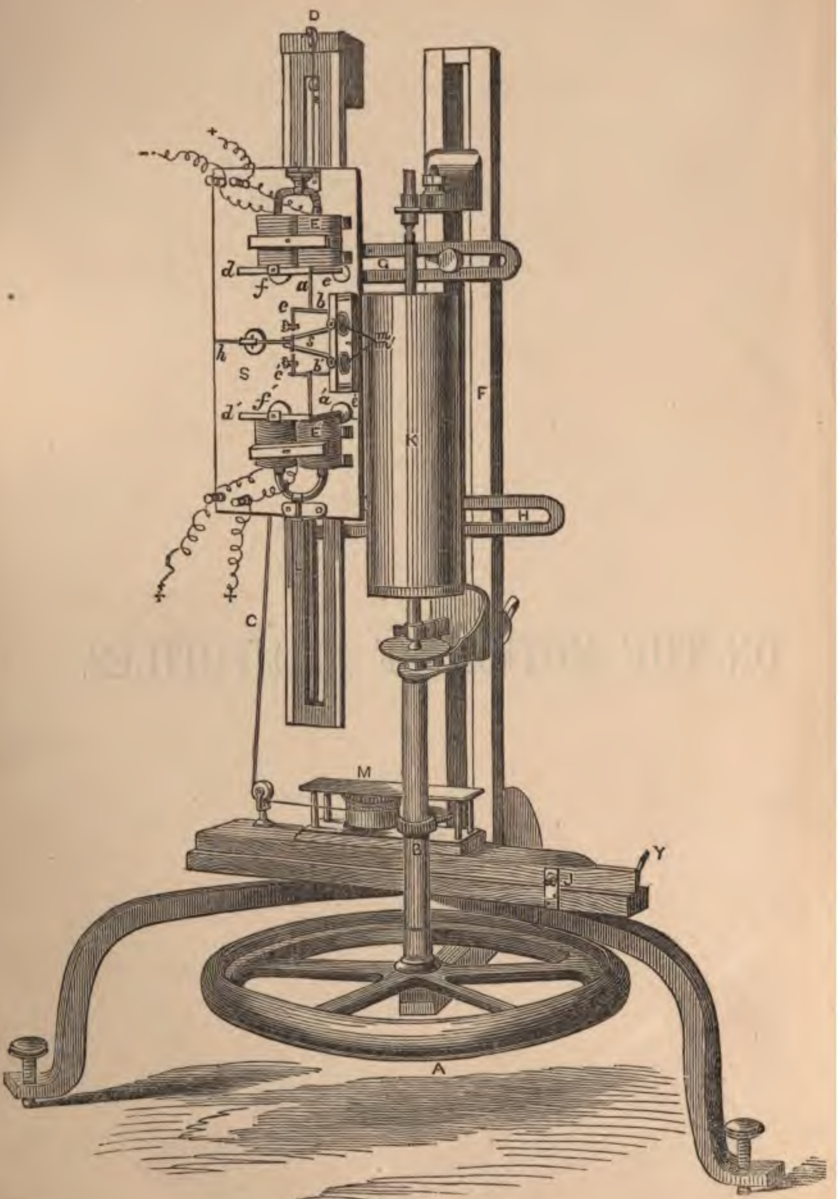

THE CLOCK-CHRONOGRAPH.

A

MATHEMATICAL TREATISE

ON THE

MOTION OF PROJECTILES,

FOUNDED CHIEFLY ON THE

RESULTS OF EXPERIMENTS

MADE WITH

THE AUTHOR'S CHRONOGRAPH.

BY

FRANCIS BASHFORTH, B.D.,
PROFESSOR OF APPLIED MATHEMATICS TO THE ADVANCED CLASS OF
ROYAL ARTILLERY OFFICERS, WOOLWICH;
AND LATE FELLOW OF ST. JOHN'S COLLEGE, CAMBRIDGE.

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1873.

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TO

MAJOR-GENERAL SIR FREDERICK ABBOTT, C.B.,

Member of the Late Council of Military Education;

AND TO

LIEUTENANT-COLONEL C. F. YOUNG, R.A.,

Late Director of Artillery Studies,

This Work is Dedicated

AS SOME ACKNOWLEDGEMENT OF

THEIR JUDICIOUS EFFORTS TO PROMOTE

THE HIGHER SCIENTIFIC TRAINING

OF

OFFICERS OF THE ROYAL ARTILLERY,

AND ALSO OF

THEIR KIND ASSISTANCE AND ENCOURAGEMENT

AFFORDED TO

THE AUTHOR.

1872.

Extract from the *Reports and Proceedings of the Ordnance Select Committee for* 1868, page 397, vol. VI.

"RESISTANCE OF AIR TO THE MOTION OF PROJECTILES."

"*Note.*—Referring to *Minute* 23,351, p 255, vol. V.:"

"The conclusions reported to the Ordnance Select Committee, with "reference to the resistance of the air to the passage of projectiles within "the limits of velocities of 1,500 to 1,100 feet, and recorded in § 2 of "the above minute,* are in accordance with the law and co-efficient "previously derived by the Rev. F. Bashforth, B.D., Professor of Applied "Mathematics to the Advanced Class of Royal Artillery Officers, from "experiments with his clock chronograph, and communicated in reports "of December 1865 and October 1866."†

---

* *The Engineer*, Nov. 15, 1867.

† *Reports, &c.*, p. 1—17.

PREFACE.

EARLY in the seventeenth century Galileo determined the path of a projectile on the supposition that the horizontal motion would continue the same as if there was no vertical motion, and that the vertical motion would continue the same as if there was no horizontal motion. But he afterwards explained that a projectile would not actually move in the parabolic path thus found, partly because he had neglected to take account of the resistance of the air, and partly because gravity did not really act in parallel lines. Mathematicians appear to have been content with this solution until Newton gave a mathematical investigation of the path described by a projectile moving under the action of gravity and the resistance of the air supposed to vary as the velocity, upon which, however, he remarked, "Cæterum, "resistentiam corporum esse in ratione veloci-"tatis, hypothesis est magis mathematica quam "naturalis." As Newton did not give a solution in the case when the resistance of the air was supposed to vary as the square of the velocity, which he believed to be the law of nature, John Bernoulli inferred that he was unable to solve this problem. Although Bernoulli gave a solution when the resistance of the air was supposed to vary as *any power* of the velocity, that solution was of no practical use in the state in which it was left by its author. Moreover, as we now know that the resistance of the air does not vary even approximately, within practical limits, according to any single power of the velocity, this solution could not, under any circumstances, have led to a correct knowledge of the laws of the resistance of the air to the motion of projectiles. Numerous mathematicians, as Euler, Legendre, Lambert, Français and Poisson have attempted to find the path of a projectile when the resistance of the air was supposed to vary as the square of the velocity. These solutions did not, however, lead to any definite conclusion respecting the law and amount of the resistance of the air. The real advance made in the science of ballistics was due to Robins, who first devised means for measuring, in a satisfactory manner, the velocities of projectiles. Afterwards Hutton, improving upon what Robins had done, obtained very good results. Numerous experiments have been made since his time, the most notable of which were those executed at Metz, which formed the basis of M. Didion's *Traité de Balistique*. But the projectiles used in those experiments were spherical shot fired from smooth-bore guns, and the results obtained did little more than confirm the previous conclusions of Hutton.

On the institution of the Advanced Class for Officers of the Royal Artillery in 1864, there was no satisfactory work on ballistics, and no experiments made with elongated shot could be found which were consistent among themselves, and therefore deserving of confidence. The Navez electro-ballistic instrument, at that time in use in this country, was one of the most unphilosophical of philosophical instruments. Feeling that the satisfactory solution of any question in gunnery depended upon the construction of a trustworthy chronograph, it therefore became my duty to recommend that a proper instrument should be procured, and that a systematic course of experiments should be undertaken to determine, in the first instance, the resistance of the air to the motion of projectiles. Although I had the hearty support of the Council of Military Education in these recommendations, I met with no encouragement from the Ordnance Select Committee and its associates, who avowed the most perfect confidence in their instrument and the results it afforded, which were, however, of no use to me. Under these circumstances I undertook the construction of my own chronograph, because it was desirable for me to retain complete control over my own invention, on account of the numerous modifications and improvements which the first example of such an instrument might naturally be expected to require. However, this roughly constructed instrument far exceeded my expectations on its first trial in November, 1865, with ten equi-distant screens.*

The chronograph, after having thus passed its first trial with success, was next used to determine the resistance of the air to elongated projectiles of the same diameter, but provided with various forms of heads. The results of these experiments shewed that it would not be necessary, for practical purposes, to employ more than one form of head in future experiments.†

In the next place, an extended series of experiments was made with a view to find according to what function of the velocity the resistance of the air varied, and also to determine whether the resistance opposed to the motion of shot did *accurately* vary according to the square of the diameter. The form of head of shot selected for these experiments was the ogival struck with a radius of one diameter and a half. The diameters of the shot varied from about three to nine inches. Also in order to obtain great variations of velocity, the charges of powder used in firing each kind of shot were made to vary greatly. Afterwards experiments were made with spherical shot fired from the guns which had been used to fire the elongated shot. In this way the resistance of the air to service projectiles was found, in a conclusive manner, for all attainable velocities above 900 feet per second. As, however, the determination of the law of resistance for velocities below 900 feet per second was of little practical importance, and as new arrangements of the screens would have been required for that purpose, it was not thought desirable to enter on that branch of the enquiry without special authority for so doing. These experiments were concluded early in 1869.*

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* *Reports, &c.*, p. 1—9.

† *Reports, &c.*, p. 10—17, and *Phil. Trans.* for 1868, p. 417—441.

Some few experiments were subsequently made by me to determine the resistance of the air to Whitworth flat-headed projectiles in consequence of an application made to me from the Department of the Director of Artillery and Stores, Woolwich.† Immediately after these experiments were completed my chronograph was removed from Shoeburyness, where it had been four years; for, having succeeded in perfecting my invention, and having trained three officers of the Royal Artillery in the use of my instrument and methods of reduction, there seemed to be no reason for me to push enquiries further, unless the subject was taken up officially and in earnest, as it was no part of my duty as Professor or Referee to invent and provide chronographs for the public service, or to make experiments, because it was distinctly stated at the first that the references themselves would always be "the application of *analysis* to some practical

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* *Reports, &c.*, p. 18—152.

† *Reports, &c.*, p. 162—169.

"question." For evidence of the uniform success of my instrument and methods of experimenting I must refer to the collection of my Reports, published by the authority of the Secretary of State for War, which have been printed just as they were written at the specified dates.

The original chronograph, called for distinction the clock-chronograph, was constructed solely with a view to determine the resistance of the air to the motion of projectiles. The labour required to reduce each experiment would render this a most inconvenient instrument for use when it was desired to measure only the initial velocity of a shot, as in the proof of gunpowder, &c. But having received repeated applications from the War Office respecting a simplified form of my chronograph for common use, I succeeded, after considerable trouble, in perfecting the gravity chronograph, hereafter fully described. This instrument, constructed originally in a rough manner, has been often used in the trial of small arm ammunition, and has proved reliable and convenient to use.

To complete the subject, I have given an account of the way in which my chronograph may be used to measure extremely short intervals of time, as I wished to explain clearly to the Committee on Explosives the right application of my methods to such cases. I have also given a critical examination of the crude form of my instrument which was brought forward by Captain Andrew Noble in 1866, and used by the Committee on Explosives, although it must be confessed that such instruments, even in their best form, are not adapted to determine the pressure of fired gunpowder in the bore of a gun.

The consideration of the motion of a projectile naturally divides itself into three parts—first, its motion in the bore of the gun; second, its motion through the air; and third, its motion during its penetration into a solid substance. In the first and third of these cases I have had no opportunity of making any experiments whatever, and therefore I have nothing new to communicate on the subject. The little that is known respecting the laws of penetration of round shot into solid substances, is due to experiments made at Metz under the direction of competent mathematicians. The short chapter on the subject here given has been adapted from M. Didion's *Traité de Balistique*. As to the pressures exerted by the gas of fired gunpowder, nothing for certain seems to be known. If we are to accept the dicta of the Committee on Explosives, the pressure of exploding pebble-powder is liable to extreme variation from round to round, even when fired under apparently the same conditions. If this be really the case, further experiments would be almost useless; but the methods of experimenting pursued by the committee are far from leading to conclusive results, as is explained in Chapter I.

In the remaining case, the whole of the data required for the calculation of the trajectories of spherical and elongated projectiles used in this treatise have been derived from recent experiments made with my clock-chronograph. The mathematical investigations are virtually the same as those of John Bernoulli, published a century and a half ago, but great labour has been required to render them practically useful. If the resistance of the air varied accurately as the cube of the velocity, and if the force of gravity acted in strictly parallel lines, it would now be easy to calculate with precision the trajectory of a shot fired at any inclination to the horizon. I mean that in no case is it necessary to have recourse to the supposition that $\frac{ds}{dx}$ may be replaced by its mean value through a moderate arc of the trajectory, as is done by M. Didion[*] and M. Heliè[†] and others. Whatever may, therefore, be the length of the arc through which the resistance can be supposed to vary as the cube of the velocity, through that arc the motion of the projectile may be accurately calculated by the methods and tables given in this treatise, excepting any deviation due to the rotation of the shot. It would be easy to take account of the variation of the density of the air corresponding to the height of any point in the trajectory. It is believed that the Tables given are sufficiently extended for all practical purposes; and when the resistance of the air to the motion of shot for velocities below 900 feet per second has been determined, it will only be necessary to furnish additional tables of coefficients corresponding to tables I. and II.

Just now the results of my eight years' labours have been arranged in a form adapted for the instruction of the Advanced Class of Royal Artillery Officers, the class itself is threatened with extinction, inasmuch as a sufficient number of candidates to form a new class did not, for some reason, offer themselves for examination last spring. In consequence of this a Committee was appointed to consider "whether the Advanced Class is of so "much benefit to the Service as to justify its con"tinuance, and whether any mode of educating the "Royal Artillery Officers in the special branches "of knowledge which the class was instituted to "teach can be suggested in preference." The Committee drew up a circular letter containing four questions,[‡] copies of which were forwarded to thirty-four Officers of the Royal Artillery varying in rank from General to Lieutenant. The

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[*] *Traité, &c.*, p. 88.

[†] *Traité, &c.*, p. 244.

[‡] The four questions were as follows:

1. Whether the existence of that class, under the present regulations, is an advantage to the Royal Artillery?

2. Whether you can suggest any preferable way of imparting the necessary Instruction to Candidates for appointments in the Scientific and Manufacturing Departments?

---

3. Whether you can account for the apparent unpopularity of the Class in the Regiment?

4. Whether you can suggest any mode of inducing Candidates to come forward in greater numbers?

Major-General F. Eardley Wilmot, R.A., replied to these questions in the following terms:

"*9a, Victoria Road, Clapham Common, 9th March*, 1872.

"Sir,

"I have the honour to acknowledge the receipt of questions relative to the "Advanced Class, Royal Artillery.

"Having already, as a Member of the Royal Commission of which Lord Dufferin "was Chairman, and also as a Member of the Committee of which Sir Edward "Warde was President, very plainly expressed an opinion, after taking a con-"siderable amount of evidence, I fear that as the reports of these two enquiries "are not considered as valuable on this point, I cannot state anything which shall "add to their force.

"But considering that your request scarcely leaves room for any other course, "I have the honour to append a few remarks in reply to the several questions.

"1. Very great. It offers the opportunity of instruction to officers of a "character which can only be obtained by a temporary removal from the ordinary "duties of the service. It provides a number of officers well qualified to take "a position among the scientific men of the day, and thus satisfies the public "that there are in a professedly scientific corps a certain proportion of officers "worthy of that character.

"It furnishes, though only a few at present, a well-instructed body of officers "so far more fitted for the duties of the various departments in which they are "required to serve, substituting specific and actual knowledge for that general "knowledge which is possessed by so many. It will eventually bring into the "departments more highly instructed officers, and providing for a continuous "supply will obviate one great hindrance to widely extended zeal, now resulting "from the supposed necessity for the continued employment of any particular "officer beyond the period usually ordered for such service. It is a positive gain "to the country to have officers capable of being utilized in any scientific duty "or enquiry, and of meeting those of other nations in this respect.

"It forms a necessary complement to the education now given at the Royal "Military Academy, especially in respect to mathematics; and it supplies a most "valuable inducement to exertion by holding out the reward of employment as "the well earned result, not of favour, but of ascertained qualification.

"2. I conclude this question does not apply to the particular 'course,' but "the general arrangement under which the class is placed. I do not think that "any plan that does not involve an entire devotion to the special course of "instruction, without attempting to carry it on with other duties, can satisfactorily "effect the object. The constant interruption and consequent difficulty of making "steady progress must have been experienced by many officers who have tried "various means for obtaining advanced education. The present system is based "on a sound principle, viz., a considerable mathematical foundation imparted "by a highly qualified and devoted professor, accompanied by the systematic "application of this to the practical duties of the service. Any departure from "this general principle would, I think, be a mistake.

"3. I conclude that 'unpopularity' is assumed as an apparent cause for there "being comparatively few Candidates. We are only just settling down into the "normal condition of peace, and consequently the effects of war and its rewards "naturally still occupy the thoughts of officers as the surest road to advancement "and employment. This helps to render 'science' for its own sake less 'popular' "than it might be. There is a dislike among officers to throw their duties upon "others, and to apply to enter the class when they know that inconvenience may "be entailed upon the brigade or the battery by their absence. There is a feeling "that employment is not *heartily* given to those that have qualified themselves "for it in this way, and that those that are thus qualified are, *ipso facto*, considered "to be disqualified for such duties as the Horse Artillery. The great majority of

Committee in their report (*C.* 589), presented to both Houses of Parliament, recognised "the great interest taken in the subject by the officers generally, and the importance which they (with hardly an exception) attach to the maintenance of *some means* of enabling officers of the corps to acquire that scientific knowledge which is so desirable in every respect." The Committee practically recommended the continuance of the class system, which provided at Woolwich instruction in Chemistry, Mechanics, Metallurgy, and Mathematics specially adapted to the wants of an

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"officers are not likely to select this particular line of preparation and employment, and would not care to have the latter, even without special preparation, hence any prospect of 'popularity' is out of the question.

"4. By placing the officers on the seconded list, and sending others to do the duty which they vacate, the objection of those that did not care to compete would be met, and a real grievance which now tells strongly against the class would be removed. I need scarcely add that a hearty encouragement from those in authority and comparative certainty of employment are essential. Under these circumstances, due notice being given, it is probable that candidates would come forward in sufficient numbers.

"In conclusion, I need hardly refer to the evidence given to the Royal Commission and Sir E. Warde's Committee. In conversation with eminent foreign officers, the 'Advanced Class' and the 'Long Course' at Shoeburyness have always been referred to as among the most valuable arrangements, and most worthy to be copied by themselves. I hold the same opinion that was expressed 35 years ago by General Lefroy and myself when urging the formation of a Royal Artillery Institution, that it is impossible to maintain a reputation for being a scientific corps without some sound basis on which to ground it, over and above that given to Cadets.

"It is true that we have had men like Boxer and Dixon, who, without this special class instruction, have created departments which are the admiration of the world. But they each had a special training and views far in advance of the generality of officers, so well known that I need not comment on them. I am satisfied that either of them would have otherwise gladly hailed such opportunities as this class affords for preparing them for their work. Having been in charge of a department myself, it is difficult for me to conceive that any officer can do otherwise than feel how enormous is the responsibility which he undertakes when he represents the special, scientific, and mechanical knowledge involved in the intelligent control and direction of so many foremen and others possessing in some cases the technical, and in some both the technical and the scientific knowledge of the work. Doubtless this alone is not sufficient to make a good Head of Department, but there is nothing in this to hinder the fullest development of that common sense fact, forbearance, and kindly feeling towards subordinates, which are necessary in every post of authority. To keep officers for a long time in specific employments until they have acquired a certain rule of thumb knowledge, and to reckon that as an equivalent for true scientific training, does not appear the wisest course, however highly they may value it, and undervalue the opposite system.

"I need hardly say that I should deplore the abolition of the class as a very serious national loss.

"I have, &c.,
"F. Eardley Wilmot, *Major-General.*

"*To the President Committee on Advanced Class.*"

Artillery Officer, at a total expense to government of about £1200 per annum. Several Officers of the Royal Artillery appearing to be distressed at seeing this large (?) sum of money "swallowed up by "the Instructional Staff," proposed that a few Artillery Officers should be selected by examination, and allowed to attend certain courses of lectures at the School of Mines, King's College, and University College, London. This formed the "alternative scheme" of the Committee, which, if adopted, would undoubtedly fail to lead to any result beneficial to the public service.

If now the system of instruction tried during the last eight years could have been pronounced a failure, there would have been some reason for its opponents to propose a change. But I maintain that the class system, instituted in 1864, has been eminently successful in training for the public service a sufficient number of Officers of great ability and unwearied industry. In support of this opinion, I refer to the official reports on the first, second, and third classes—to the text books prepared by Officers who have passed through the advanced class—to the valuable papers contributed to the Proceedings of the Royal Artillery Institution by former members of the advanced class; and lastly, to the satisfactory manner in which every Officer, who has received an appointment after leaving the advanced class, has discharged the duties of his office. There are certainly several other Officers of the Royal Artillery who have qualified by passing successfully the examinations of the advanced class, but have not hitherto received any appointment; while they have seen prizes, which have been held out to them as inducements to work, given to others whose scientific attainments had never been tested. And this goes far to explain the existing dissatisfaction, and the paucity of candidates for admission into the fifth advanced class. It, therefore, seems to me extremely opportune that public attention should have been so distinctly called at the present time to the higher scientific education of Officers of the Royal Artillery, and to some of the discouragements under which professors and their pupils have so long laboured.

As none of the civilian lecturers pretend to have even the most elementary knowledge of the regimental duties of an Artillery Officer, it is plain that their teaching is not likely to interfere with the prospects of those Officers who confine their attention to strictly professional duties. But just now great changes are taking place in the armaments of all nations, and it is a question who shall have the direction of the changes in this country. Shall selected Officers of the Royal Artillery receive, first, a high scientific training, and, when found qualified, be appointed to some subordinate posts, where they can *carry on their education*, and avail themselves of the opportunity to apply to practical purposes the instruction they have received in Chemistry, Mathematics, &c., so as to *gradually fit themselves* for the highest posts in the manufacturing departments? Or, shall the heads of departments be Officers who do not even pretend to any scientific knowledge, and who must, therefore, in deciding most important questions, be dependent for assistance upon subordinates, or inventors, or scientific men called in for the occasion. To me it appears that such duties would be best performed by Officers of the Royal Artillery, provided they possessed the necessary scientific knowledge, because they would be likely to be best acquainted with the wants of the service. And even if they did not feel sufficient confidence to deal single-handed with any important question, they would be able to consult distinguished scientific men, without being under any obligation to follow implicitly their advice.

The nation has suffered incredible losses of late years from the want of proper scientific training in its advisers. Take the Armstrong breechloading system, a failure, upon which many millions sterling have been wasted. The "grip" in front of the seat of the shot was calculated to *impede the initial motion of the shot*, and therefore to cause the powder to exert its utmost destructive effect on the gun. It ought, therefore, to have been foreseen that such a contrivance must fail.

But in dealing with the muzzle-loaders, the very opposite course was taken. Some kind of *increasing twist* of rifling was adopted with a view to save the gun by *facilitating the initial motion* of the shot. On what principle, it may be asked, was the *particular form* of increasing twist chosen? The failure of several very heavy guns in time of peace seems to indicate that an error of a very grave kind has been committed in adopting the Woolwich system of rifling for those guns. Now the proper form of rifling depends upon the nature of the powder to be used. If the propelling force acting upon the shot could be rendered perfectly uniform, then the gun ought to be rifled with a uniform twist. Consequently, if the use of pebble-powder has a tendency to produce uniformity of pressure of the gas propelling the shot, the proper form of rifling must approximate to the uniform twist.

Quite recently we have heard much of the great power of a new 16-pounder field gun. When, however, the gun was tried with its proper carriage, the firing of a few rounds sufficed to break the axles of the gun-carriages. It need hardly be stated, either that the strength of axles should be perfectly understood, or that everything relating to the recoil of a gun, so far as it depends upon the weight and calibre of the gun, upon the weight of the shot, or upon the kind of powder, ought to be perfectly well known. The present difficulty may be got over by increasing the strength of the axles, and so adding to the weight of the gun, or by reducing the charge, and so diminishing the boasted powers of the gun, but in either case the gun ceases to be what it was intended to be.

The very numerous and costly experiments on the penetration of iron plates throw little light upon the subject, because they have been made on no system, by the use of shot which generally broke up in penetrating. Much valuable information might be derived from experiments carefully conducted on a small scale, by the help of a reliable chronograph, with shot made of the Whitworth metal, or some other metal which did not break up on penetrating.

If these and other questions of the same kind were made the subjects of careful experimental investigation under the direction of the best mathematicians of the day, most instructive lessons would be furnished to the Officers of the advanced class, and the conclusions arrived at would prove of the highest value to the nation. I here offer the results of my eight years' labours, voluntarily carried on under many discouragements and difficulties, as my contribution towards an improved state of things. The want of hearty official support has led to a great waste of labour, because I have had to do things for myself which ought to have been done for me. So long as the educational and the experimental departments do not work well together, it must be to the great disadvantage of the public service.

In carrying out the experiments which form the foundation of the present treatise, I have been greatly indebted to Major-General Sir F. Abbott, C.B., and to Colonel C. F. Young, R.A., as already stated. At Shoeburyness, on all occasions, I received every possible assistance in making the experiments. My best thanks are, therefore, due to Major-General F. Eardley Wilmot, R.A., to Major Alderson, R.A., and to Captain Ellis, R.A. To Captain J. P. Morgan, R.A.; Captain A. Ford, R.A., and Captain J. Sladen, R.A., I am indebted for most valuable assistance in making the experiments and in the laborious work of their reduction. I must also express my obligations to the Officers of the Royal Artillery Institution for the assistance derived from the use of their workshops in carrying out my plans.

For further information of a more practical character, I must refer the reader to the excellent treatise recently published by Lieutenant-Colonel C. H. Owen, R.A., Professor of Artillery at the Royal Military Academy, Woolwich, on the Principles and Practice of Modern Artillery.

November, 1872.

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ON THE MOTION OF PROJECTILES.

CHAPTER I.

INTRODUCTION.

ON THE MEASUREMENT OF THE ELASTIC FORCE OF EXPLODED GUNPOWDER.

1. Robins made experiments about 1740 with a view to determine the pressure exerted by fired gunpowder. He came to the conclusion that when powder was exploded it produced about 250 times its own volume of gas under the atmospheric pressure. The elastic force of common air was found to be increased four-fold when raised to a temperature equal to that at which iron begins to be white hot. Robins thence concluded that when powder filling the chamber in which it is enclosed is exploded, it will exert a pressure equal to 1000 times that of the atmosphere.* This result was far below the truth.

2. The best experiments of this kind were made by Rumford towards the close of last century. He measured *directly* the pressure exerted by the gas at the instant of explosion, and so avoided calculations based on mere hypothetical views. He employed a cylindrical barrel B (fig. 1) about a quarter of an inch in diameter and capable of containing $25\frac{1}{2}$ grains of fine gunpowder. The barrel, which was placed in a vertical position, was carefully closed by the pressure of a heavy weight resting on the hemisphere E, and acting in the direction indicated by the arrow. The ball W when heated was employed to fire the charge. Various charges were used, and by trial it was found what weight

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* *Robins' Tracts*, p. 161.

each charge was just capable of lifting.* The unit of volume by which the quantity of powder was expressed was the one-thousandth part of the volume of the barrel. Suppose x to be the volume of the charge of powder so expressed, and y the pressure in pounds per square inch exerted by the gas, then

$$y = 27{\cdot}615x^{1+{\cdot}0004x}.$$

3. The above formula did not, however, correctly represent the experimental results for charges of powder more than sufficient to fill three-fifths of the chamber. For higher charges the elastic force of the gas appeared to be greater than that given by the formula. These results of Rumford must be considered highly satisfactory so far as they go, but it is quite possible that, if a much larger chamber and higher charges had been used, less heat would have been absorbed, and consequently higher pressures would have been registered. Rumford's papers are well worth a careful perusal, as his methods are, in general, so direct and simple; but his calculations respecting the power required to burst his gun are fanciful and inconclusive. The results of Rumford, however, do not enable us to calculate the motion of a shot propelled in the bore of a gun by the explosion of powder, because, in general, the shot is moving while the explosion of the powder is in progress, and at no time is it possible to say what is the ratio of the volume of powder actually exploded to the volume occupied by its gas.

4. Captain Rodman, by the help of his pressure gauge, carried out numerous experiments in America to determine the pressure exerted by fired gunpowder, but his results were not sufficiently consistent among themselves to merit any great confidence. He gave a very partial trial to what he called his velocimeter, by which he found the *law of recoil* of the gun mounted in the gun pendulum. This was the first step towards a satisfactory system of experimenting. But the mass of the gun being too great, its initial motion was too insignificant to give the law of pressure of the gas with accuracy.

5. Experiments were made at Essen in 1867 by General Mayevski, who took another step in the right direction, but still he did not arrive at any satisfactory result. A Prussian

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* *Philosophical Transactions*, 1797.

breech-loading gun of 4 was used, which fired an elongated lead-coated projectile (fig. 3). A hole was bored through the breech piece in the axis of the gun. Through this hole an iron rod M was passed and screwed into the shot with which the gun was loaded. Arrangements were made at the free end of the rod M to break two wires a, a', connected with a Boulengé Chronoscope, and placed in certain known positions. In this way attempts were made to measure the times in which different parts of the bore were described by the shot. But, unfortunately, only *one* observation was made for each round fired, and that by a chronoscope capable of measuring only *one* interval of time. General Mayevski thus confesses the unsatisfactory nature of his results:—"Les résultats "obtenus font voir que la durée du trajet du premier pouce "est très-longue *et très-variée*, comparativement à celles des "déplacements suivants, de sorte que les durées que met le "projectile à parcourir différents trajets ne peuvent être "déterminées avec précision qu' à partir d'un certain dé"placement de sa position initiale. *C'est pour cette raison que* "*l'origine des durées a été prise dans la plupart des expériences* "*à ¼ de pouce, et dans quelques-unes à* 1 *pouce de la position* "*initiale du projectile.*"*

6. Thus the most important point in the experiments was given up. But it appears to me that if a suggestion published by me in 1866 had been attended to, this difficulty might, in a great degree, have been overcome. "The only "method which appears to me to hold out any prospect of "success is one to which Captain Rodman gave a very partial "trial. He mounted a gun in the old gun pendulum. A "cylinder was placed with its axis parallel to the bore of "the gun. When the gun recoiled it drew back a tracing "point, which marked a straight line on the surface of the "cylinder at rest. If, whilst the gun was stationary, the "cylinder was made to rotate, the tracing point described a "circle on the surface of the cylinder. If now the cylinder "be made to rotate rapidly and left to itself, and if the gun "be fired, the point will trace out a curve on the surface "of the cylinder, the ordinate of which will represent the "time occupied by the gun in recoiling through a space equal "to the abscissa. The *law* of the work done to produce "the recoil thus becomes known. By measuring the initial "velocity of the shot, the total amount of work done by the

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* *Royal Belgian Academy*, Oct. 10, 1868.

"powder is found. The law of pressure of the gas would "be found with greater exactness *if the tracing point was* "*connected with the projectile.* This method of experimenting "seems to be the only one likely to give a satisfactory result, "for if the rotation of the cylinder be uniform for the very "short time the explosion is in progress, there can be no "doubt that the coordinates of the diagram would give us "a connection between the time and space; and knowing "the weight and the velocity of the moving body at any "one point, we can tell the amount of pressure that was "acting upon it at any instant, or for any position. From "what has been said, it is evidently of great importance in "the *proof* of gunpowder, that besides the trial for *initial* "velocity, *there should be some test of the stress thrown on* "*the gun.*"*

7. Arrangements might be made for measuring the angular velocity of the cylinder at the time of firing the gun. It is evident that the proposed arrangement would connect *time* and *space* in a satisfactory manner, provided (1) the angular velocity of the cylinder did not change sensibly during the progress of the explosion, and (2) that the rod attached to the marking point did not stretch sensibly. If the curve was one of *continuous curvature* then it would be plain that there was no percussive action of the powder, and no "*waves* "*of pressure.*" When high charges were used, General Mayevski found that the iron rod screwed into the shot was torn asunder near the shot. Probably in any case a short rod would have stood sufficiently long to give the *initial* motion of the shot correctly. But in order to determine the law of pressure throughout the whole length of the bore, it would be necessary to use a rod tapering in substance from the screwed end. In order to avoid a variable amount of windage, it would be advisable to substitute for the solid rod a cylinder, from which an internal conical cavity had been bored.

8. It is evident that the mass of the gun is too great, while the mass of the shot is too small, to admit of being used with perfect success in determining the pressure of the gas of exploding powder. It appears to me that the proposed

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* *Proceedings of the Royal Artillery Institution*, 1866, p. 189, and *Description of a Chronograph, &c.*, p. 29.

breech-loading gun of Captain Morgan, R.A.,* would enable this difficulty to be completely overcome. In this case the barrel is closed by a piston *A* (fig. 2) connected with a heavy mass of metal. When the gun is fired the shot *D* is driven forward, and the breech piece *A* is driven backward, while the barrel remains nearly stationary. Here the recoiling breech piece might be made 10 or 20 times the weight of the shot, and there could be no difficulty in obtaining the law of its recoil, from which might be deduced the law of the propelling pressure. Such an experiment would enable us to calculate the motion of the shot on the supposition that the pressure per square inch exerted by the gas on the breech piece and on the shot were equal at every instant. By comparing the calculated and measured initial velocity of the shot the precision of the experiment would be tested. The resistance due to rifling, or the friction of the lead coat, might be simultaneously determined from the forward motion of the barrel, just as the pressure of the gas was determined from the recoil of the breech piece.

9. A Committee on explosive substances has been more or less engaged in this country since 1866, but hitherto nothing more than the most meagre statements of their proceedings have been published. In the beginning of their labours the Committee troubled themselves to little purpose about chronoscopes. They desired to measure the velocity at different points in the bore of the gun, and from this they hoped to deduce the corresponding pressures of the propelling gas. In the first place (Nov. 1866) they tried the Leurs instrument then just received, but in vain.† From the *Pall Mall Gazette* (July 15, 1868) it appears that the Committee had then become embarrassed with riches, for they had obtained a Schultz Chronoscope, and were daily expecting a Noble Chronoscope. A confident hope was expressed that, through the instrumentality of these inventions, "some of the most important problems relating to gunnery" would be solved in a satisfactory manner. Fabulous stories were told about the performances of these instruments. The measurement of time with an error so great as the 5,000,000th of a second was easily accounted for, although in both these instruments the spark from a secondary coil was used as the

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* *Journal of the United Service Institution* for 1870, and *Proceedings of the Royal Artillery Institution, Woolwich*, Feb. 1871, p. 145.

† *Proceedings of the Ordnance Select Committee*, 1866, p. 350.

recording agent, which, to compare small things with great, strikes as directly or as capriciously as a discharge of forked lightning. Thus Gloesener remarks that "l'etincelle ne "paraît pas éclater normalment de la pointe à la plaque; "elle suit le chemin le plus facile ou qui oppose le moins de "résistance, et non pas le plus court. La direction de son "trajet dépend de différentes causes; de la nature, de "l'hétérogénéité, de l'etat hygrométrique, et de la con-"ductibilité du papier; la forme, la conductibilité de la "pointe et l'état de l'air qui l'entoure influent sur le trajet "qui suit l'etincelle."*

10. These two chronoscopes also agree in another point, their cylinders are driven by *toothed* wheels. In the Noble Chronoscope "there are four toothed wheels, each travelling "five times as fast as the one behind it," which are used to impart and maintain the velocity of the short cylinders upon whose surfaces the records are received. The chattering noise made when the instrument is at work plainly shews that the cylinders are in a state of excessive vibration. Up to the present time I am not aware that the Committee have published full particulars of a single experiment made with this instrument in a precise. form intelligible to the scientific world.

11. It is manifest that little reliance can be placed on the results given by chronoscopes where the records are received on the surfaces of cylinders which are subject to more or less vibration in consequence of toothed wheels being used to drive them. But there are other equally strong objections to the use of all chronographs whatever in the determination of the pressure of fired gunpowder, by means of observations made at *six* or *eight points* first at one end and then at the other end of the bore of the gun. In order to determine a rapidly varying *velocity* it is necessary to measure with extreme accuracy the short time δt in which a short space δs is described, and then the ratio $\frac{\delta s}{\delta t}$ may be taken as the velocity at the middle point of the space δs. But in order to determine the rapidly varying *pressure* of the gas which is propelling the shot at any moment, it is necessary to determine the increment of velocity δv which

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* *Traité Général des Applications de l'Electricité*, t. I. p. 449.

takes place in time δt, and then the ratio $\frac{\delta v}{\delta t}$ will represent the accelerating force acting upon the shot. Now when the spark discharged from the secondary coil is used as the recording agent, *accuracy in space* can only be secured by cutting the primary wires precisely at predetermined points. The Committee on explosives met with this practical difficulty of securing accuracy in space in the very simplest case when they attempted to break six primary circuits *simultaneously*, for they remark that "*great difficulties* were, "however, experienced in securing a *simultaneous* rupture "of the primary wires, *and the only method found perfectly* "*satisfactory* was to place the whole of them on a small screen "close to the muzzle of a rifle; on firing a flat-headed bullet "the whole of the wires may be cut *nearly simultaneously*, "and the action of the instrument examined." If so great a difficulty was encountered in such a simple case, it may be asked what means were used by the Committee to secure, in actual experiment, the rupture of the primary wires by the passage of the shot *exactly* at the appointed positions. The contrivance, shewn in fig. 4, was used by the Committee for this purpose. The elongated shot A rubbed against the inclined plane of the shearing instrument D, which was half an inch in length. The primary wire to be sheared is *ee*, and *f* is a steady pin.* It is manifestly impossible to say what would be the exact positions of the shot in each case, when the primary wires were ruptured by such a contrivance.

12. But suppose this first and greatest difficulty surmounted, and that accuracy in *space* could be secured, we must consider the means used by the Committee to secure accuracy in the records made by the spark on the rotating cylinders. The Committee on explosives confess that, "It "is obvious that the results furnished by an instrument "intended to measure the very small intervals of time "necessary for the investigations in which the Committee "have been engaged, *would be liable to be received with great* "*suspicion* were there no means of testing the accuracy of "the instrument; accordingly, one of the chief objects in its "design was to arrange that the *accuracy* of the indications "could at any time be *tested with facility*."† The cylinders

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* *Preliminary Report*, 1870, p. 6.

† Ibid.

were accordingly put in rapid rotation, the primary wires were cut by firing at them a flat-headed bullet, *as nearly simultaneously as possible*, and the records were then examined. Now in this test it is to be observed that the rupture of all the primary wires was nearly *instantaneous*, and consequently nothing whatever depended upon the known uniform and steady motion of the cylinders on which the records were made, or upon the satisfactory action of the stop-clock. The test employed did not test the instrument as used in any experiment. If the experiment tested anything it merely tested the value of the secondary spark as a recording agent, the value of which was well known before. Although it has often been proposed to employ the spark from a secondary coil in similar cases, I am not acquainted with any results obtained by its aid in any single case which are of the slightest scientific value. Still it is difficult to find any other more satisfactory means of making records if chronoscopes are to be used in such experiments, and it therefore becomes necessary in the first place to consider whether the deviations of the spark from the normal line are such as would materially impair the value of the proposed experiments. If I had used the secondary spark, as originally proposed, the errors caused by the known deviation of the spark would have been sufficient to vitiate all my experiments made to determine the resistance of the air to the motion of projectiles. It is, however, extremely probable that the errors in space due to the shearing apparatus would be far more injurious than the errors in registration by the secondary spark in the mode of experimenting pursued by the Committee on explosives.

13. But the chief instrument employed by the Committee was the Rodman pressure gauge, where the indenting knife was replaced by a copper cylinder to be crushed by the pressure of the gas acting on a piston of known area. This method has the great merit of being simple and *direct*, and, provided it gave consistent results, there would be no reason to dispute its value, so far as *relative results* were sufficient. But the Committee have noticed a surprising difference between the recorded pressures when the cylinder to be compressed was placed near the bore of the gun and when placed at a distance from it, which does not appear to admit of a satisfactory explanation. The Committee remark that "In experimenting with the 8-inch gun, the copper cylinders "by which the pressure is measured at the front of the

"cartridge have been placed occasionally in the same position "as the Rodman knives, which were employed for that "purpose during the early stages of the Committee's ex-"periments, that is to say, they were put at the outside "surface of the gun, instead of being situated close to the "bore. In all five cases when this was done *an enormous "increase of compression resulted, &c.*"* It is quite necessary that this anomaly should be explained satisfactorily before any confidence can be placed in the indications of the crusher gauge.

14. It is natural to enquire what means were used in order to deduce from a given compression of a copper cylinder the pressure to which it had been subjected. The Committee state that "A series of experiments having been made by "means of a testing machine to determine the pressure "required to produce a definite amount of compression in "copper cylinders corresponding to those used in the instru-"ment, the *tabulated results furnished* a means whereby the "amount of compression produced in the 'crusher' becomes "a direct indication of the pressure at that part of the bore "where the plug is inserted."† This was certainly a very ready, but it can hardly be considered a satisfactory, way of determining the pressure to which the cylinders had been subjected. In the first place the modes of action of the pressure of the gas and of the testing machine are quite different. It cannot be safely assumed that copper cylinders can be manufactured of such uniform quality that all will shew equal compressions corresponding to equal great pressures. The metal of which some of the cylinders were composed appears to have been too soft, regard being had to the pressures they were intended to measure, for one case is mentioned where a cylinder was compressed from 0·500 inch to 0·285 inch in length.

15. The Committee state that "the pressures have also "been calculated, as before, from the various rates of move-"ment in the bore indicated on the Noble Chronoscope, and it "has been highly satisfactory to find that all the observations "of pressure and velocity thus independently taken have *cor-"roborated and confirmed one another in a remarkable degree*, "with the exception of certain discrepancies as regards pres-"sure, which have been confined to quick-burning powders,

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* *Progress Report*, p. 7. † *Preliminary Report*, p. 8.

"and which the Committee hope to explain in their detailed "report."* Now it is difficult to imagine how this mutual confirmation is possible, except in cases where the maximum pressure of the gas is attained before the shot moves sensibly from its seat. For instance, it is quite impossible for the crusher to confirm the pressures exhibited by the pressure curves of Plate IX. of the preliminary report. It is quite impossible for a chronoscope to reveal the variation of pressure said to exist in different parts of the powder chamber. Thus there were three crusher gauges; namely, *A* placed in the axis of the gun and at the bottom of the bore, *B* in the bore opposite the centre of the charge, and *C* approximately in front of the charge. Three rounds of Waltham Abbey pebble powder, of density 1·78, were fired from an 8-inch gun, loaded with a spherical shot weighing 69 lbs., with the following results:†

Charge.	Pressure at *A*.	Pressure at *B*.	Pressure at *C*.
16 lbs.	4½ tons.	3¼ tons.	2 tons.
18 "	2½ "	2½ "	3 "
20 "	3 "	5 "	2½ "

For these low pressures we should expect "the crusher gauge" to give particularly consistent results. But we cannot be satisfied that the pressures indicated at *A*, or at *B*, or at *C*, follow any law corresponding to the charges of powder which produced them. It is unfortunate that charges of 14, 12, 10, &c. lbs. were not also tried. Another good test of the value of "the crusher gauge" would have been obtained if, for every round fired, crusher plugs had been inserted at equal intervals along the bore of the gun.

16. There is another peculiarity in the experiments made by the Committee on explosives. It appears that, from the nature of the shearing arrangement (fig. 4) in connection with the Noble Chronoscope, it was found necessary to employ a mechanically fitting projectile. For instance, a 7·995 in. bolt was fired from an 8-inch gun. Mention is also made of a windage of 0·02 in., while the service windage is generally 0·08 in. Now it is impossible to insist too strongly on the necessity of carrying out experiments of this kind under strictly practical conditions. The usual amount of windage may afford great relief to the gun, by allowing part of the gas at a high tension to escape, and so act as a safety valve.

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[*] *Quarterly Proceedings, &c.*, 1870, p. 280.

[†] *Progress Report*, p. 6.

17. After numerous experiments made with the 8-inch and 10-inch guns, the Committee on explosives were employed to measure the pressures in the bore of the 35-ton gun. When the gun had a bore of 11·6 in., 35 rounds were fired with shot of 700 lbs., and charges of pebble-powder varying from 75 lbs. to 130 lbs. Afterwards, with a bore of 12 in., 33 rounds were fired with shot of 700 lbs. and charges of pebble-powder varying from 110 lbs. to 120 lbs. After this an "incipient crack" was found in the steel lining of the gun. The initial velocity reached its maximum as an "11·6-inch gun, with 120 lb. charges, when it was 1370 ft. "per second, with a pressure on the powder chamber of "47 tons per square inch; whilst it fell off to 1346 ft. with "a 130 lb. charge, though it gave 63 tons pressure on the "base of the projectile, showing that the extra powder was "unconsumed, or that the exit of the shot was impeded."* An explanation given in *The Standard* † may apply in this case. "When the gun was tried with 130 lbs. of powder "there was an idea that it failed to burn all the charge, "inasmuch as the velocity *appeared* to fall off. But the gun "was *only once* fired with this excessive charge, and it is "now understood that the *velocity taken on that occasion was* "*fallacious*, the electric screen nearest the gun being broken "by the blast from the muzzle before the projectile reached "it. *It has been found necessary to take great care to prevent* "*a recurrence of this disturbing cause.*" This is just what might have been expected from the very defective and untrustworthy chronometric instruments used, which are quite insufficient for the performance of exact experiments.

18. It is further stated that "the combined pressures "were 47 tons on the square inch with 120 lb. charges in "the 11·6-inch bore, but these were reduced to about 35 tons "in the 12-inch bore. *Suddenly*, at the eighteenth 120 lb. "charge, the extraordinary internal pressure of 66 tons per "square inch was registered in the powder chamber; and "the steel tube being calculated to withstand only 55 tons, "an 'incipient crack' took place in the bottom groove near "the seat of the shot. I have not seen all the registered "pressures, but those of the last four 120 lb. charges varied "from 40 to 66 tons, *the initial velocity with* 46·8 *tons pressure* "*being six feet more than when the pressure was* 66 *tons.* The

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* Captain W. Dawson, R.N., Royal United Service Institution, Feb., 1872.
† Nov. 15, 1871.

“muzzle velocity and maximum pressures given by the last
“four 120 lb. pebble-powder charges in the 12-inch bore,
“with 700 lb. projectiles, were:—

		Maximum Powder–Pressures at		
Velocity.	Total Work.	Axis of Gun.	Vent.	Projectile.
1366 feet.	9059 foot-tons.	46·8 tons.	35·2 tons.	45·4 tons.
1360 ”	8973 ”	66·0 ”	42·6 ”	53·2 ”
1334 ”	8639 ”	44·6 ”	34·2 ”	46·8 ”
1334 ”	8639 ”	37·6 ”	27·0 ”	39·6 ”

“The muzzle-velocity and pressures with smaller charges of
“pebble-powder are said not to present the same variety;
“probably, because the effort of the shot to escape from
“them is more successful......Returning to the last four
“120 lb. charges and the crack, let us ask, why did the
“greatest pressure give the lesser velocity, if the exit of
“the shot was not impeded? *Why this variation in the*
“*powder-pressure at all?*”

19. Further, it has been stated that Captain A. Noble, a member of the Committee on explosives “has fired by
“electricity as much as ¾ lb. of powder confined in cylinders
“of steel tempered in oil. The cylinders, which were 2 in.
“internal diameter and 1½ calibres thick, usually expanded
“·002″ or ·003″, and one as much as ·02″, external diameter.
“......Some ‘crusher gauges’ were placed inside, and from
“them, I believe, Captain Noble deduced a maximum
“pressure of 40 tons. I do not know, however, what
“reliance is to be placed on their indication under such
“extreme pressures as they must have been subjected to;
“nor can I reconcile their indications with the expanding
“of the cylinders, *which is more in harmony with Rumford's*
“*results.*”*

This pressure of 40 tons per square inch is only about two-thirds of that said to have been subsequently registered in the proof of the 35-ton gun. It is undoubtedly a most difficult matter to measure the pressure of the gas of fired gunpowder. The same powder may, under apparently the same circumstances, at different times exert a pressure liable to extreme variations. This is, however, at present little more than an unsupported theory adopted to explain discordant results, which may in the end turn out to be due to the manner in which the experiments have been conducted.

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* Captain Morgan, R.A., in *Proceedings of the Royal Artillery Institution*, 1871, p. 420.

And, regard being had to the striking performances of guns at long ranges, which depend so much upon the uniform action of the gunpowder, most thoughtful people will be disposed to question the results arrived at by the Committee on explosives. See a valuable paper by Captain Morgan, R.A., on the Determination of the Explosive Force of Gunpowder.*

ON THE CALCULATION OF INITIAL VELOCITIES OF PROJECTILES.

20. The motion of a shot in the bore of a gun has been usually calculated on the supposition (1) that all the powder was converted into gas before the shot moved; (2) that there was no escape of gas by windage; and (3) that the pressure of the gas varied inversely as its volume for every position of the shot. The last of these conditions would probably hold in no case, but the first two might be approximately satisfied by the Armstrong breech-loading gun, where, however, there is an enormous and unknown amount of friction. Sometimes it has been assumed that the work done on the shot by the powder varied as the weight of the powder. But this is not approximately true even for moderate variations of the charge, the gun and shot remaining unchanged. For instance, it was found by firing a hollow elongated studded shot, weighing 23·84 lbs., from a 5-inch rifled gun, that the average useful effect per pound of powder used was 147,921 foot pounds, for a charge $\frac{1}{3}$ of the weight of the shot; 177,268 for a charge of $\frac{1}{4}$; 187,032 for a charge of $\frac{1}{6}$; 170,964 for a charge of $\frac{1}{8}$; and 159,875 for a charge of $\frac{1}{12}$.† In this case it appears that the useful effect of each pound of powder attained a maximum when the weight of the charge was about $\frac{1}{6}$ of that of the shot. Again, when a solid shot weighing $47\frac{2}{3}$ lbs., and of the same external form as the hollow shot, was fired from the same gun, the useful effect of each pound of powder was 170,534 foot-pounds for a charge of $\frac{1}{6}$ the weight of the shot; 192,071 for a charge of $\frac{1}{8}$; 199,242 for a charge of $\frac{5}{48}$; and 200,834 for a charge of $\frac{1}{12}$. Although the shot for our experiments with the 3, 5, 7, and 9-inch guns were very carefully manufactured with a view to determine the resistance of the air, the guns from which they were fired would afford varying amounts of windage depending upon their different degrees

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* *Proceedings of the Royal Artillery Institution*, 1871, p. 413.

† *Reports, &c.*, p. 51.

of wear and tear. Also the lengths of the bores of the guns did not follow any law dependent on the calibres of the guns. Consequently the useful effect per pound of powder obtained from one gun did not admit of direct comparison with that obtained from another gun.

21. It was observed by Rumford* that when charges of coarse grained powder were used, unconsumed grains were frequently blown out of the gun, while some grains shewed clear indications of having been once ignited and of having been afterwards extinguished. It must be manifest, therefore, from the above examples of the behaviour of powder, that its explosion is not instantaneous, and unfortunately we have no knowledge of the *law* of its explosion, depending as it does upon its composition, upon the mode of its manufacture, upon the size and form of the cartridge, upon the point of its ignition, upon the state of the atmosphere, and upon the pressure under which the explosion takes place. Powder will ignite, but it will not explode in vacuo. Hence it appears to be undesirable to attempt to make any mathematical investigations respecting initial velocity so far as it depends upon the charge and weight of projectile, especially as the law which governs it may be easily determined by a short course of careful experiments when the service powder has been decided upon.†

22. But in obtaining a given initial velocity of the shot, it is necessary to consider the stress thrown upon the gun. The more uniform the pressure of the gas can be rendered, so as to distribute the work done on the shot along the bore, the better it is for the gun. A detonating mixture would explode so suddenly and violently that it would destroy the gun and perhaps fracture the shot without imparting to it a high initial velocity. Gun cotton ignites so rapidly that all attempts to retard its combustion have hitherto failed to make it useful in large charges. If the powder ignites quickly the whole of the charge will be exploded during the initial motion of the shot, and the tension of the gas at first will be very high, but it will generally fall quickly as the volume of the gas is increased. Such a powder would try severely the endurance of the gun. But when the powder burns slowly, as the shot moves the explosion will be going on in a manner calculated to sustain the pressure

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* *Philosophical Transactions*, 1797.

† *Reports, &c.*, pp. 46, 47.

of the propelling gas throughout the whole length of the bore. In this way it is found that a slow burning powder may give even a much higher initial velocity to a shot than a quick burning powder, and at the same time exert a much less destructive effect on the gun.

23. When quick burning powder was used for large guns it was most important to consider the *initial* motion of the shot, so as to provide, as far as possible, for an early increase of space for the gas to occupy, for the motion of the shot must at first be comparatively slow, and there was a danger that the gas, being confined in a limited space, might burst the gun. It seems, therefore, that the law laid down by Professor Hélie was in that case a sound one; namely, that every obstruction to the *initial* motion of the shot ought to be removed.* This consideration gave rise to the rifling of guns with an increasing twist. Now it is plain that modern rifled guns firing elongated shot have a much greater strain thrown upon them than the old smooth bore service guns of equal calibre. But it does not yet clearly appear whether this is due chiefly to the increased weight of elongated shot and the diminution of the escape of gas by windage, or whether the rifling has any perceptible destructive effect beyond that due to the cutting away of the metal of which the gun is composed. If two elongated shot were fired from a gun rifled with a uniform twist, one studded and the other without studs, under otherwise identical conditions, and if their *initial* motions were *accurately* determined, it would be clearly shewn what effect the uniform twist had upon the *initial* pressure exerted by the gas. It is known that the *total* "work done" in giving rotation to a shot is quite insignificant when compared with that required to give the usual velocity of translation, but it is not known what effect a uniform twist of the rifling has upon the *initial* motion of the shot. This is a subject worthy of careful experimental investigation, for if the increasing twist does not sensibly relieve the stress upon the gun by facilitating the initial forward motion of the shot, it fails to effect that saving of the gun for which it was designed. The more rapidly the powder explodes the greater is the apparent necessity for an increasing twist in the rifling; and, on the other hand, the slowly burning powder recently introduced into the service must tend to to diminish the practical importance

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* *Hélie Traité*, p. 400.

of the increasing twist, and perhaps render it entirely unnecessary.

24. It is undoubtedly right in principle to free the initial motion of the shot, so far as possible, from all needless obstructions. The increasing twist has, as we have seen, been tried in deference to this principle, only it is at present doubtful whether the advantages secured by its adoption counterbalance the practical disadvantages of its employment. But the Armstrong system of breech-loading ignored all considerations of this kind, for a "grip" in the bore was placed just in front of the seat of the shot, while the shot was covered with a thin coating of lead to take the rifling. An experiment was made at Woolwich in 1865 to determine the statical pressure required to force a 12-pound shot along the bore of an Armstrong breech-loading gun.* It was found that a pressure of from 16·25 tons to 20 tons was necessary to force a cold 12 lb. shot through the "grip" in front of the shot chamber, and a pressure of from 3 to 5·5 tons to force it along the bore. It is plain that the shot could not move forward before the tension of the exploding powder was sufficient to exert a pressure of 16 tons on the base of a 3-inch shot, and even after that the shot would move slowly. This would cause so *great a loss of time* that probably the whole of the powder would be exploded before the shot had moved sensibly from its seat, and consequently the *gas would exert its greatest possible destructive force upon the gun.* This error in principle, combined with the use of the destructive powder formerly in use in this country, termed *poudre brutale* or *poudre brisante* on the continent, seems to be quite sufficient to account for the failure of the Armstrong system. The 12-pounders firing shot 3 inches in diameter and the 40-pounders firing shot of 4¾ inches in diameter appear to have been so far encouraging, in the first instance, that the English Government proceeded with the manufacture of 110-pounders firing lead-coated projectiles 7 inches in diameter. General Peel has stated that in 1860-1, £2,830,625, and in 1861-2, £3,006,049, were spent in the manufacture of warlike and miscellaneous stores, "a "great portion of which was for the 110-pounder Armstrong "guns which had been adopted" *without any sufficient trial.* Repeated failures merely led the late Ordnance Select Com-

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* *Quarterly Proceedings of the Ordnance Select Committee*, 1865, p. 23.

mittee to search for a more enduring metal of which to form their breech pieces.

25. The failure of the 7-inch Armstrong breech-loaders led to the adoption of the muzzle-loading system for 7-inch guns and for those of larger calibre. As it was impossible to use lead-coated projectiles for muzzle-loading guns, it became necessary to try other kinds which have been found to give equally good results. After the large muzzle-loading guns had proved successful, the same system was adopted even for field-guns, and thus the Armstrong system was completely superseded. Still it appears that the question of breech versus muzzle-loading for large guns has not been finally settled. The recently introduced slow burning powder requires a long bore for its useful consumption, while the limited space in forts and ships restricts very much the lengths of muzzle-loading guns.

26. Inasmuch as Krupp has manufactured breech-loading guns of 9¼ inches bore firing *lead-coated* shot of 300 lbs., which successfully competed at Tegel with the Woolwich or muzzle-loading gun of 9 inches bore, it is plain that the failure of the Armstrong system for 110-pounders cannot be simply ascribed to the use of lead-coated projectiles. Neither can it be supposed that Krupp's success is due to the superiority of the metal of which he constructs his guns. It may be asked, does he contract the bore of his gun just in front of the shot, so as greatly to impede its initial motion?

27. Sir William Armstrong, in his address as President of the Institution of Mechanical Engineers in 1869, when speaking of gunpowder, confessed that a new light had just "dawned upon the subject," which altered the prospect. A comparison of dates leads to the conclusion that this new light was derived by him from the results of the Tegel experiments, during the progress of which it was proved that a slow burning powder might be found, which would throw less stress upon the gun and give a higher initial velocity to the shot than the quick burning powder in use in this country. The different effects produced by different explosive agents long ago suggested that there might be different degrees of violence exerted by powders which gave the same initial velocity to the shot. Shortly after I was appointed referee to the Ordnance Select Committee in 1864, I in vain suggested that a few inexpensive experiments

should be made to determine the law of explosion of gunpowder. As no attention whatever was paid to my recommendation, when I was writing a description of my chronograph in 1866, I took the opportunity to record my opinion as follows:—"From what has been said, it is "evidently of great importance in the proof of gunpowder "that, besides the trial for *initial velocity*, there should be "*some test of the stress thrown on the gun.*"* At present, 1872, two Boulengé chronoscopes are used to measure the initial velocity of the proof shot, and the crusher gauge is used to measure the maximum pressure of pebble-powder. If such a system, *giving reliable results*, had been introduced ten years ago it might have saved many millions of money and many vain attempts to transgress the laws of nature.

28. If, as seems probable, the progress of events should render it necessary to reconsider the system of breech-loading, it is to be hoped that lead-coated projectiles will be abandoned and that the same kind of shot will be used for one bore, be the gun loaded at the muzzle or the breech. The lead-coated projectiles are said to have the good property of preventing the scoring of the guns, while the objections urged against their use are numerous and important. If the same shot was made suitable for firing from a breech or a muzzle-loading gun, the two systems might be in use at the same time without causing any confusion, and that system might finally be adopted which seemed to be best adapted to the wants of the service.

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* *Proceedings of the Royal Artillery Institution*, 1866, p. 190, and *Description of a Chronograph*, p. 30

CHAPTER II.

ON THE MOTION OF A PROJECTILE IN VACUO.

29. In our investigations we shall suppose gravity to act in parallel lines and to exert a constant accelerating force, g. The projectile will therefore move in the vertical plane in which it is projected. Let the point of projection be taken as the origin, and let x, y be the coordinates of the centre of gravity of the projectile at the time t, the axis of y being vertical and that of x being the horizontal line in which the vertical plane of projection intersects the horizontal plane through the origin. Let also V be the velocity and α the angle of projection.

The equations of motion are

$$\frac{d^2x}{dt^2}=0;\ \frac{d^2y}{dt^2}=-g.$$

Integrating, we have

$$\left.\begin{aligned}\frac{dx}{dt}&=\text{const.}=V\cos\alpha\\ \frac{dy}{dt}&=\text{const.}-gt=V\sin\alpha-gt\end{aligned}\right\}\ldots\ldots\ldots\ldots(1).$$

Also $\qquad x=Vt\cos\alpha$, and $y=Vt\sin\alpha-\tfrac{1}{2}gt^2\ldots\ldots\ldots(2)$,

because when $t=0$, $x=0$, and $y=0$.

These two equations (2) give the coordinates of the projectile at any given time t. Also the velocity v may be found from equations (1), for

$$v^2=\left(\frac{ds}{dt}\right)^2=\left(\frac{dx}{dt}\right)^2+\left(\frac{dy}{dt}\right)^2$$

$$=V^2\cos^2\alpha+\{V^2\sin^2\alpha-2gtV\sin\alpha+g^2t^2\}$$

$$=V^2-2g\left(tV\sin\alpha-\tfrac{1}{2}gt^2\right)=V^2-2gy\ldots\ldots\ldots(3).$$

Eliminating t between equations (2), we have

$$y = x \tan\alpha - \frac{g}{2V^2 \cos^2\alpha} x^2 \quad\text{................(4)},$$

the equation to the path of the projectile, which is a parabola with its axis vertical.

30. The equation to a parabola with its axis parallel to the axis of y, its latus rectum l, and its vertex A at the point hk, is

$$(x-h)^2 = l(k-y), \text{ since } PN^2 = l \times AN \text{ (fig. 5)};$$

or $$x^2 - 2xh + h^2 = lk - ly.$$

If this curve passes through the origin, the condition $x=0$ when $y=0$ gives $h^2 = lk$, leaving $y = \frac{2h}{l} x - \frac{1}{l} x^2$. Comparing this with (4) and equating coefficients of like powers of x, we have

$$\frac{2h}{l} = \tan\alpha, \text{ and } \frac{1}{l} = \frac{g}{2V^2 \cos^2\alpha},$$

from which it appears that

$$h = \frac{V^2 \sin 2\alpha}{2g}, \; k = \frac{V^2 \sin^2\alpha}{2g}, \text{ and } l = \frac{2V^2 \cos^2\alpha}{g}.$$

Or, the equation (4) may be put under the form

$$\left(x - \frac{V^2 \sin 2\alpha}{2g}\right)^2 = \frac{2V^2 \cos^2\alpha}{g}\left(-y + \frac{V^2 \sin^2\alpha}{2g}\right).$$

So that the coordinates of the vertex are $\frac{V^2 \sin 2\alpha}{2g}$ and $\frac{V^2 \sin^2\alpha}{2g}$, and the latus rectum equals $\frac{2V^2 \cos^2\alpha}{g}$.

The coordinates of the focus of the parabola are

$$h = \frac{V^2}{2g} \sin 2\alpha,$$

and

$$k - \frac{l}{4} = \frac{V^2 \sin^2\alpha}{2g} - \frac{V^2 \cos^2\alpha}{2g} = \frac{V^2}{2g}(\sin^2\alpha - \cos^2\alpha) = -\frac{V^2 \cos 2\alpha}{2g}.$$

The height of the directrix above the horizontal plane through the point of projection $= k + \frac{l}{4} = \frac{V^2}{2g} = HX$.

If x, y be the coordinates of p then $np = XH - mp = \frac{V^2}{2g} - y$. Now the velocity acquired by a body falling freely from rest through a height np

$$= \sqrt{(2g \times np)} = \sqrt{\left\{2g\left(\frac{V^2}{2g} - y\right)\right\}} = \sqrt{(V^2 - 2gy)}$$

equals the velocity which the projectile would have in its path at the point p, by equation (3) of Art. 29.

31. To find the range on a horizontal plane passing through the point of projection we have $y = 0$, and equation (4) becomes

$$0 = \mathrm{X} \tan\alpha - \frac{g\mathrm{X}^2}{2V^2\cos^2\alpha},$$

which gives $\mathrm{X} = 0$ or $\mathrm{X} = \frac{2V^2}{g}\sin\alpha\cos\alpha = OR$ (fig. 5).

In order to find the time of flight we observe that the horizontal velocity $= \frac{dx}{dt} = V\cos\alpha$ is constant, and therefore the time in which the range X is described

$$= \frac{\mathrm{X}}{V\cos\alpha} = \frac{2V\sin\alpha}{g}.$$

And generally when the shot has reached a point whose abscissa is x, the time of flight $= t = \frac{x}{V\cos\alpha}$ by equation (2).

32. If it be required to find the range and time of flight on a horizontal plane at the distance k' above the point of projection we have $+k' = x\tan\alpha - \frac{gx^2}{2V^2\cos^2\alpha}$, an equation which gives

$$x = \frac{V^2\sin\alpha\cos\alpha}{g} \pm \sqrt{\left\{\frac{2V^2\cos^2\alpha}{g}\left(-k' + \frac{V^2\sin^2\alpha}{2g}\right)\right\}}.$$

If k' be $+$ and $< \frac{V^2\sin^2\alpha}{2g}$ this equation gives two real values of x, On and On', corresponding to the ascending and descending branches (fig. 6).

If k' be $+$ and $= \frac{V^2\sin^2\alpha}{2g}$, then the two values of x are equal, or the shot just touches the plane at A.

If k' be $+$ and $> \frac{V^2 \sin^2\alpha}{2g}$, then both values of x are impossible and the projectile never reaches the plane.

If k' be negative, or if the plane be *below* the point of projection, there are always two real values of x, as Om, Om'; Om giving that point in which the trajectory would intersect the given plane if it was produced backwards in Op.

33. In the same manner we must proceed if we wish to find where a given projectile will strike a given object represented by the equation $y=f(x)$, for we have two equations $y = x \tan\alpha - \frac{gx^2}{2V^2\cos^2\alpha}$ and $y=f(x)$, given to find x and y.

We have found the range on the horizontal plane $\text{X} = \frac{V^2}{g}\sin 2\alpha$, where for a given value of V it is plain that X will be a maximum when $\sin 2\alpha = 1 = \sin\frac{1}{2}\pi$ or when $\alpha = \frac{1}{4}\pi$.

34. The inclination θ, of the path of the projectile to the horizon corresponding to the time t, is given by equations (2), for

$$\tan\theta = \frac{dy}{dx} = \frac{\frac{dy}{dt}}{\frac{dx}{dt}} = \frac{V\sin\alpha - gt}{V\cos\alpha}$$

in terms of t and known quantities; or differentiating equation (4) we obtain

$$\tan\theta = \frac{dy}{dx} = \tan\alpha - \frac{gx}{V^2\cos^2\alpha}$$

in terms of x and known quantities.

35. It may be useful to treat the motion of a projectile in vacuo in the same manner as we shall treat the motion of a projectile in a resisting medium. The equations of motion are

$$\frac{d^2x}{dt^2} = 0\,;\ \frac{d^2y}{dt^2} = -g\,;$$

giving $$\frac{dx}{dt} = V\cos\alpha,\ \frac{dy}{dt} = V\sin\alpha - gt.$$

Let
$$\tan\theta = p = \frac{dy}{dx} = \frac{\frac{dy}{dt}}{\frac{dx}{dt}},$$

then
$$\frac{dp}{dx} = \frac{\frac{dx}{dt}\frac{d^2y}{dt^2} - \frac{dy}{dt}\frac{d^2x}{dt^2}}{\left(\frac{dx}{dt}\right)^3} = \frac{\frac{d^2y}{dt^2}}{\left(\frac{dx}{dt}\right)^2} = -\frac{g}{\left(\frac{dx}{dt}\right)^2} = -\frac{g}{V^2\cos^2\alpha};$$

therefore $\dfrac{dx}{dp} = -\dfrac{V^2\cos^2\alpha}{g}$,

and
$$x = -\frac{V^2\cos^2\alpha}{g}\int dp = -\frac{V^2\cos^2\alpha}{g}\,{}^{\alpha}\!\!\int^{\theta}(1+\tan^2\theta)\,d\theta$$
$$= -\frac{V^2\cos^2\alpha}{g}\,{}^{\alpha}X_0^{\theta}.$$

Also since
$$\frac{dy}{dx} = p,$$
$$y = \int p\,dx = -\frac{V^2\cos^2\alpha}{g}\int p\,dp$$
$$= -\frac{V^2\cos^2\alpha}{g}\,{}^{\alpha}\!\!\int^{\theta}(\tan\theta + \tan^3\theta)\,d\theta = -\frac{V^2\cos^2\alpha}{g}\,{}^{\alpha}Y_0^{\theta}.$$

For the time we have
$$\frac{dt}{dp} = \frac{dt}{dx}\cdot\frac{dx}{dp} = \frac{1}{V\cos\alpha}\times -\frac{V^2\cos^2\alpha}{g} = -\frac{V\cos\alpha}{g};$$

therefore
$$t = -\frac{V\cos\alpha}{g}\int dp = -\frac{V\cos\alpha}{g}\,{}^{\alpha}\!\!\int^{\theta}(1+\tan^2\theta)\,d\theta$$
$$= -\frac{V\cos\alpha}{g}\,{}^{\alpha}T_0^{\theta}.$$

The numerical values of ${}^{\alpha}X_0^{\theta} = {}^{\alpha}X_0^{0} - {}^{\theta}X_0^{0}$, for the ascending branch; and for the descending branch ${}^{\alpha}X_0^{\theta} = {}^{\alpha}X_0^{0} + {}^{0}X_0^{\theta}$. In the same manner the numerical values of ${}^{\alpha}Y_0^{\theta}$ and ${}^{\alpha}T_0^{\theta}$ may be found in the Table $\gamma = 0{\cdot}00$, p. 40.

CHAPTER III.

ON THE RESISTANCE OF THE AIR.

36. THE received theory of the resistance of the air to the motion of bodies is unsatisfactory in the extreme. It is based on the erroneous supposition that the moving body disturbs those particles of air alone which lie in its way, and no account is taken of the condensation of air in front of the body, or of the lateral disturbance, or of the disturbance propagated through the air when the velocity of the disturbing body is below the velocity of the sound wave. Although the form of the rear of the moving body is known to modify the resistance opposed to its motion by the air, no account is taken of that matter in the commonly received theory. It is further probable that the amount of the resistance of the air to the motion of a body, at a given velocity, will in some measure depend upon whether the motion of the body is being *accelerated* or *retarded*. In consequence of these difficulties, it has long been felt that actual experiment would alone determine the resistance of the air in each particular case with satisfactory accuracy. The important effect of the air in modifying the motion of projectiles has caused numerous experiments to be made with a view to determine the amount of its resistance to the motion of spherical balls, and, more recently, to the motion of elongated shot furnished with various forms of heads.

37. The earliest of these experiments of any value were made by Robins (1742), and by Hutton (1783–91). They were remarkably successful, considering the inherent defects of the ballistic pendulum, which was used by them in the measurement of velocities. In order to determine the resistance of the air to a projectile, it is necessary to find the velocity lost by it in moving through a given distance. But as the ballistic pendulum allowed only one velocity to be measured for each round, it was necessary to fire a number of rounds with the pendulum placed at one distance from the gun, and afterwards, having changed the distance between

the gun and the pendulum, to fire another set of rounds under as nearly as possible the same conditions. The distance between the gun and pendulum in Hutton's experiments varied from 30 to 430 feet. The weights of his *spherical* balls varied from about 1 to 6 lbs., and their diameters from 2 to 3½ inches. In the course of these experiments, the weight of the pendulum was increased from about 500 to 1800 lbs. Although a gun may be charged to all appearance in the same manner each time, there will in general be found to be considerable variations in the initial velocities of the shot, which are important when exact experiments are being attempted with the aid of the ballistic pendulum. As the distance between the gun and the pendulum is increased, the difficulty of making the shot strike the receiver properly is also increased. The ballistic pendulum also limits the *weights* of the shot which it is possible to use in experiments of this kind.

38. In 1839 and 1840, experiments on the resistance of the air to the motion of spherical shot were carried on at Metz, by order of the French Minister for War, by a commission of which MM. Piobert, Morin, and Didion were members.* The weights of the projectiles used in these experiments varied from about 11 to 50 lbs., and their diameters from 4·0 to 8·7 inches. The distance between the gun and the ballistic pendulum varied from about 50 to 330 feet. The mean weight of the receiver was nearly six tons.

39. M. Didion has given a comparison between the results obtained at Metz and those derived from the previous experiments of Robins and Hutton by a careful recalculation of their observations. Didion's experiments gave $\rho' = 0{\cdot}02694\,(1 + 0{\cdot}0023v)$ when the shot moved with a velocity of v metres per second. The experiments of Hutton made with one pound balls gave $\rho' = 0{\cdot}02693\,(1 + 0{\cdot}002587v)$, and those of Robins, made with small-arm bullets $\frac{3}{4}$ inch in diameter moving with low velocities, gave the same result as the Metz experiments. But the experiments of Hutton made with balls of three and of six pounds, as well as those of Robins made with small-arm bullets moving at high velocities, appeared to give higher values of ρ'. M. Didion,

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* Didion, *Lois de la Résistance de l'Air*, p. 22.

therefore made the first term in the value of ρ' constant in all cases and $=0{\cdot}027$. Then putting $\rho'=0{\cdot}027\,(1+xv)$, and giving ρ' its experimental value, and substituting for v the mean velocity of the shot during the experiment, the numerical value of x was determined in each case. In this way it was found from Hutton's experiments with balls of one pound moving with a mean velocity of 400 metres per second, that $x=0{\cdot}00257$; with balls of three pounds moving with a mean velocity of 430 metres per second, that $x=0{\cdot}00274$; and with balls of six pounds moving with a mean velocity of 450 metres per second, that $x=0{\cdot}00272$. The experiments of Robins made with small arms gave, for a mean velocity of 455 metres per second, $x=0{\cdot}00451$. In conclusion, M. Didion adopted the formula $\rho'=0{\cdot}027\,(1+0{\cdot}0023v)$ as the result of the most recent experiments made at Metz, by the use of service projectiles, by the aid of instruments of the greatest precision. Applying now the formula of M. Didion, $\rho'=0{\cdot}027\,(1+0{\cdot}0023v)$, and also the new formula derived from the mean of Hutton's experiments with three and six pound balls, $\rho'=0{\cdot}027\,(1+0{\cdot}00273v)$, to calculate the resistance of the air to a spherical shot 10 inches in diameter moving with a velocity of 1400 feet, we find that M. Didion's formula gives 1088 lbs., and that the formula derived by him from Hutton's experiments gives 1189 lbs. Recent experiments have given 1204 lbs.,* shewing that Hutton's experiments were more exact than those of Didion, which fact leads to the conclusion that Hutton had reached the limiting weight of shot which could with advantage be employed in conjunction with the ballistic pendulum. Notwithstanding this, very large ballistic and gun pendulums were constructed at the Elswick engine works in 1855 for the experimental establishment under the Ordnance Select Committee at Shoeburyness, which were "designed to afford "data for calulating the initial velocity of cannon shot." But these monsters have never been used for the purpose for which they are said to have been designed.† This is probably the most costly ballistic pendulum that ever was constructed. Elaborate models of these unused instruments may be seen in the Rotunda at Woolwich, which are said to have cost £800.

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* *Reports, &c.*, p. 121.

† Since the above was written I have been informed that these ballistic pendulums have been taken down, as the sheds were wanted for manufacturing purposes.

40. The first proposal to use electricity in ballistic experiments seems to have been made by Professor Wheatstone, in 1840, who shortly afterwards caused instruments to be constructed for that purpose. About this time Colonel Konstantinoff, of the Russian Artillery, consulted Professor Wheatstone respecting a chronoscope which he desired to obtain. He afterwards (March, 1843) employed M. Breguet, of Paris, to construct an instrument for him. The problem proposed by Colonel Konstantinoff was very clearly stated as follows: "Disposer un instrument qui pût indiquer et "conserver trente ou quarante observations successives, faites "dans des espaces de temps très rapprochés, d'un phénomène "se passant plus ou moins loin de l'endroit où se trouve "placé l'instrument d'observation."* Great credit is due to Colonel Konstantinoff for thus clearly stating the problem to be solved. The construction of the instrument was commenced in June, 1843, and the work was completed in May, 1844. In June, 1845, M. Breguet was expecting to hear the result of a trial of his instrument at St. Petersburg, but I am not aware that any experiments made with his instrument have ever been published. M. Morin has remarked that the problem was not solved in a manner completely satisfactory.†

41. Another instrument of the same kind was brought before the English scientific world by General Sabine, in his address as President of the Royal Society (Nov. 1866). He said: "A chronoscope recently devised by Captain "Schultz of the French Artillery appears, as far as can "be judged previous to a practical trial, to correspond to "these conditions, and to be likely to supply a means of "surmounting the difficulty; it is not improbable that it "will be tried in the present year." Although the Committee on gun cotton wisely abstained from taking any further steps in the matter, General Lefroy, R.A., F.R.S., as President of the Ordnance Select Committee, applied to have a Schultz Chronoscope procured for the use of the Committee, in consequence of the favourable terms in which the President of the Royal Society had spoken of that invention. This chronoscope was really brought forward in 1859, and was somewhat ostentatiously exhibited at Paris in 1867. It was noticed in *The Engineer*,‡ and in *The*

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* Moigno, *Traité de Télégraphie*, 1849, p. 95.

† Du Moncel, *Exposé, &c.*, Vol. II., p. 340.

‡ *The Engineer* for Dec. 1867, p. 509.

Practical Mechanic's Journal, where it was stated that "Captain Schultz, in fact, finds that he can observe and "register time to the *ten-millionth* of a second."* Far more satisfactory would it have been if evidence had been produced of the satisfactory use of this chronoscope in some actual experiment. In due time the Schultz instrument arrived at Woolwich (July, 1868), but I am not aware that it has ever been employed in this or any other country in any experiment where more than two screens were used. A few instances of its employment in the measurement of single velocities were given by Colonel Benet,† which results are of no scientific value.

42. The instrument most extensively used in this country down to 1866, was the Navez Electro-Ballistic Pendulum, which was introduced from Belgium by Colonel Younghusband, R.A., F.R.S., and for some time a member of the late Ordnance Select Committee. Perhaps no instrument has had so much money wasted upon it in the way of experiment as that of Navez, and yet it gave no results of any value. In confirmation of this opinion I refer to the *Ballistic Reports of the late Ordnance Select Committee*, 80, V. 114, pp. 34 (1862); 84, V. 132, pp. 130 (1863); and to 84, V. 132, pp. 284 (1865). All these labours with the Navez instrument led to the adoption in England of Didion's methods of calculation, and the reprinting of a selection of his tables in 1865, *even after these things had been discarded at Metz!* It has been pointed out that Hutton's experiments gave better results than those of Didion, shewing clearly that the science of ballistics had made no progress in the interval 1800—1865. Now the instruments of Breguet and Schultz appear to have been such decided failures, that nothing has ever been heard of any important experiments having even been attempted by their aid, so that in such cases the loss of the money paid for the instruments was about the total loss. But the case was different with the Navez instrument; it afforded no means of testing the accuracy of its indications; it was not sufficiently bad to secure its immediate rejection by the late Ordnance Select Committee. At one time, it gave very fair results, and at another, it gave extremely bad results. As an instance of this I will refer to the experiments made by the help of two Navez Pendulums, under the direction of General Lefroy, R.A.,

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* *Practical Mechanic's Journal*, for Oct., 1867.

† *Electro-ballistic Machines*, 1866.

to determine the loss of velocity of 12 lb. and 70 lb. elongated shot, for the information and guidance of the Armstrong and Whitworth Committee. Each result was a *mean* obtained from five good rounds, and the means did not differ notably from the individual quantities. We now know that the experiments with the 70 lb. shot were *very fair*, and that the experiments with the 12 lb. shot *were extremely bad.*

43. Such was the state of our knowledge of the resistance of the air to the motion of projectiles, when, in 1864, it was decided to form an Advanced Class for the scientific instruction of Officers in the Royal Artillery. On that occasion the council of Military Education sought my assistance in the department of Applied Mathematics, and afterwards the duties of Referee to the late Ordnance Select Committee in Mathematical questions were imposed upon me. A very short examination of the experiments, which had then been made under their direction, shewed me that, in general, they had been made on no systematic plan, or, where there was some approach to system, the results were discordant. I felt it to be my duty therefore to recommend the construction of a chronometric instrument, which should be capable of giving the times occupied by a shot in passing over a *series of successive equal spaces.* This recommendation was made by me before I was aware that Colonel Konstantinoff had felt and expressed the same want. The Committee had, however, lavished such extravagant praise upon their Navez, that they could not listen to any proposals for the introduction of a rival chronoscope, and in the end I was driven to the hard necessity of inventing and constructing my own instrument. Late in 1865 the new Chronograph was tried in Woolwich Marshes with 10 screens with perfect success. It was afterwards removed to Shoeburyness, where it remained from 1866—1870, during which time the experiments were made which are described in the "Reports on experiments made with the Bashforth Chronograph, 1865—1870.* The Council of Military Education took great interest in these questions, and it was through their influence that authority was obtained for carrying out experiments in the interest of the technical education of officers in the Royal Artillery.

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* Reference to this publication is made under the short title, *Reports, &c.* London, published by W. Clowes and Sons; Harrison and Sons; W. H. Allen and Co.; Longman and Co.; and Trübner and Co. Price, 1*s.* pp. 170.

44. After the Chronograph had passed its first trial with success in December 1865, it appeared desirable to make use of it, in the first instance, to determine the resistance of the air to elongated projectiles of a given diameter and weight, but varying in the forms of their heads. The forms selected were the hemispherical, the prolate hemispheroidal having axes in the ratio 1 to 2, and two ogivals struck with radii of one, and of two diameters of the shot. Ten solid shot were provided of each kind, but unfortunately sufficient care was not taken to secure equality of weight. In addition twenty hollow ogival-headed shot, ten of each kind, were provided. All the rounds were fired with a charge of 5 lbs. of powder, so that the hollow shot had a much higher initial velocity and consequently a much higher velocity of rotation than the solid shot. The diameter of the shot usually denoted by d was 4·7 inches. The distance between successive screens was 150 feet denoted by l, and $2b$ was the coefficient of resistance. The following is a statement of the average results:

Gun.	Form of Head.	No. of Rounds.	Mean Weight of Shot $= w$. lbs.	Mean Initial Velocity f-s.	Mean value of bl^2.	$2000b\frac{w}{d^2}$.	Date.
40 Pr.	½ sphere	5	39·33	1202	·000840	·0001329	Oct.,
M. L.	½ spheroid	4	38·69	1196	·000669	·0001043	1866.
	Ogival (1 diam)	10	21·81	1541	·001245	·0001097	
	Ogival (2 diam)	8	21·94	1545	001181	·0001042	

The range of velocities obtained in these experiments was not sufficient to indicate a departure from the cubic law of resistance. It is apparent from the above values of $bw \div d^2$ that the resistance to the hemispherical head was decidedly greater than that opposed to the remaining three forms. The resistance of the air to the hemispheroidal and the ogival heads varied so little that it was plain that any of these forms most serviceable in other respects might be safely adopted. The slight variations in the resistances to the three latter forms lead to the conclusion that the amount of resistance offered by the air to the motion of elongated shot is little affected by the more or less pointed apex, but depends chiefly upon the form of the head near its junction with the cylindrical body of the shot. In this neighbourhood the forms of the hemispheroidal head and the ogival head struck with a radius of two diameters are the same, and the resistances are little different. For a detailed account of these experiments see the *Philosophical Transactions* for 1868,* and the published reports.†

45. It was still necessary to seek for a satisfactory answer to the two questions: (1) Does the resistance of the air vary as the cube of the velocity for all practical velocities of the projectile? and (2) does the resistance of the air vary exactly as the square of the diameter? With a view to solve these questions the following officers were associated with me to carry out an extended series of experiments with guns of 3, 5, 7, and 9-inch calibres:

Lieut.-Colonel C. F. Young, R.A., Director of Artillery Studies.

Lieut.-Colonel C. H. Owen, R.A., Professor of Artillery, R.M.A.

Captain J. P. Morgan, R.A., now Assistant Superintendent of the Royal Gunpowder Factory, Waltham.

Captain A. Ford, R.A., now Assistant Director of Artillery Studies.

Captain J. Sladen, R.A., now Assistant Instructor Royal Laboratory.

The last three officers had then recently completed a two years' course of instruction in the Advanced Class. In turn they superintended the firing of the gun and assisted in the chronograph room, which was about a quarter of a mile from the range. Most of the reductions of the experiments were made by the same three officers in the most satisfactory manner. As the following treatise is founded entirely upon the results of experiments made with my chronograph, 1865—1870, it will be proper to give a brief description of the instrument, and shew in what manner the reductions of the observations have been made, referring the reader for fuller information to the published description of the chronograph.‡

46. The chronograph was designed with a view to secure the following conditions:

(1) The time to be measured by a clock *going uniformly.*

(2) The instrument to be capable of measuring the times

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* *Phil. Trans.*, 1868, p. 417.

† *Reports, &c.*, p. 10.

‡ Bell and Daldy, 1866; *Proceedings of the Royal Artillery Institution*, 1866, p. 161; and *Revue de Technologie Militaire*, t. VI., p. 199.

occupied by a cannon ball in passing over any number of *successive equal spaces.*

(3) The instrument to be capable of measuring the *longest known time* of flight of a shot or shell.

(4) Every beat of the clock to be recorded by the *interruption* of the same galvanic current, and under precisely the *same conditions.*

(5) The time of passing each screen to be recorded by the momentary *interruption* of a second galvanic current, and under precisely the *same conditions.*

(6) Provision to be made for keeping all the strings or wires of the screens in an *uniform state of tension.*

47. In contriving my instrument I at once abandoned all attempts to drive the cylinder at a known uniform angular velocity. The frontispiece gives a general view of the instrument as constructed and used in experiment. A is a fly wheel mounted on a vertical axis. K is a cylinder intended to be covered with paper prepared to receive the records made by the two markers m, m'. When the fly wheel is spun by hand, the toothed wheel B allows the string C to unwind from the drum M, and so lower the stage S, which descends smoothly by its own weight along the slide L. Two electro-magnets E, E' are fixed to the stage S. These magnets, by means of arms a, a', work levers b, b', which give motion to the markers m, m'. A lever h acts upon the springs s, and so raises the markers m, m', or keeps them gently pressed against the paper mounted on the cylinder K. If we suppose the markers depressed, and the fly wheel spun, *as a gyroscope*, the markers m, m' will trace two parallel spiral lines upon the cylinder. But if we cause a galvanic current to circulate round the lower electro-magnet E', and if the galvanic circuit be so arranged that the pendulum of a half-seconds clock shall *interrupt and restore* the current once every double swing, then we shall have upon the spiral traced by m' records made every second. The forces tending to destroy the motion of the fly wheel are the resistance of the air and the friction at the bearings, and at the marking points m, m'. The only force tending to drive the heavy fly wheel is that derived from the tension of the string C acting through the toothed wheel B, about three-quarters of an inch in radius. The cylinder K and the fly wheel

A are respectively 4 and 18 inches in diameter. The object of these arrangements was to remove all causes which might be likely to disturb the *perfect smoothness* of the rotation of the cylinder. As I knew that it was quite impossible to secure *sufficient uniformity* of angular velocity of the cylinder, I merely endeavoured to secure a *uniformity of loss* of angular velocity. The regular beating of the clock gave a diminishing scale of time on the cylinder. By means of necessary corrections and interpolations this scale was further divided into a correct scale of tenths of a second. It was not necessary to carry the subdivisions of the scale further than tenths of a second, because it was found that intervals of time less than the twentieth of a second could always be treated by the ordinary method of proportional parts.

48. Suppose now a second galvanic current to circulate about the other electro-magnet *E*, and also to pass through ten or more equidistant screens, so contrived that the passage of a shot through any screen shall cause a *momentary interruption* of the galvanic current at that screen, but allow the current to be restored again before the shot can arrive at the next screen. Each interruption of the current will be recorded by the marker *m* upon the rotating cylinder *K*. Afterwards the clock and screen records are measured off, starting from some line drawn on the surface of the cylinder parallel to its axis.

49. It is well known that there will always be some loss of time between the interruption of a current and the registration of the corresponding record. As it is impossible entirely to remove this difficulty care must be taken that each marker shall make its own records under precisely the same circumstances, so that we may be permitted to assume that the *loss of time* is the *same* for every record made by the same marker. The clock records present no difficulty because the pendulum goes on swinging and breaking contact once a second, hour after hour, and we have no reason to suppose that the loss of time in making the records will vary in the course of 10 or 20 seconds. But precautions are required to secure a like condition for the screen records. If the galvanic current was allowed to circulate for a few minutes about the electro-magnet *E*, and then was interrupted in rapid succession 10 or 15 times in a second, it might be expected that the remaining mag-

netism would have an effect in delaying the records which would gradually decrease with each successive interruption. This would be a very injurious kind of error, for the varying loss of time would *follow a law*, and therefore it would be impossible to eliminate it. The following arrangement was made with a view to obviate this difficulty. The action of the lever *h*, when used to raise the markers *m*, *m'* from the paper, simultaneously breaks the galvanic current belonging to the electro-magnet *E*, and restores the circuit when the markers are depressed preparatory to the firing of the gun. The manner in which this is effected is shewn by fig. 15. The screen circuit is joined at *A* and *B*. When the switch *l* stands as represented in the figure, the current is broken. While the screens are being mended *l* is brought in contact with *m*, and thus the ringing of the bell indicates the proceedings on the range. And when *l* is brought in contact with *n* the galvanic current circulates about the electro-magnet *E*. But between the depressing of the markers and the firing of the gun there is in general a little delay which requires further precautions. A self-acting contact breaker (fig. 14) is placed in the circuit and near the gun. When the firing party are ready, a lever *ab* is raised and a pin *f* is inserted, which turns the galvanic current through the contact breaker *D*. The same motion of the hand that pulls the lanyard to fire the gun withdraws the above-mentioned pin *f*, and allows the lever *ab* to be brought down into the position *ac* by a spring, and so shutting out the contact breaker *D*, completes the circuit just before the shot reaches the first screen. Further, it is not important for the losses of time to be absolutely equal for records made by the markers *m* and *m'*, provided they be small for each marker.

50. The most troublesome part of my undertaking was the invention of a proper screen, which would allow the *same* galvanic circuit to be used for *all* the screens on the range, the records being made by the momentary interruption of this single circuit. Provision had to be made for closing the circuit interrupted at one screen before the shot arrived at the next screen. This was satisfactorily accomplished in the manner shewn in fig. 12. Springs *b*, *d*, *f*, ... were formed of hard brass wire, and were fixed in wood as represented. The ends of the springs passed through holes in copper plates as *a*, *c*, *e*, &c. Wood being a non-conductor, the current which entered at *a* passed through the spring *b*,

into the plate of copper *c*; thence by the spring *d* it entered the plate of copper *e*, and so on along the whole length of the top of the screen. The tops of all the screens and the chronograph were included in one circuit, as shewn in fig. 13. The holes in the plates of copper through which the springs projected were about half an inch in length, and the springs, when not held down by weights in contact with the lower edges, rose up by their own elasticity and remained in contact with the upper edges of their holes. For an experiment the springs were held down by *equal* weights suspended by strong sewing cotton so as to form the screens. These springs were about two inches apart for experiments with bores of 3 inches and upwards. The shot in its course broke one or more threads as it passed through each screen, and so, releasing one or more springs, caused the marker *m* to register a corresponding record.

51. When every precaution had been taken it was found that there were still little irregularities in the readings of several successive records. The corrections required were most simply performed by plotting on an enlarged scale, and then drawing a curve. They may also be performed by differencing the readings and applying small corrections required to render the second or third orders of differences regular. It has been suggested that the method of least squares might have been employed to obtain the most probable results from our experiments. But I very much doubt whether any other method of dealing with our observations would have given results so accurate and certain as the one adopted. We had no supposition to make respecting *the law* connecting space and time which we were in search of, we merely assumed that there was a law. By inspection we could see whether one mode of correction gave the sum of the squares of the errors greater or less than another, when there was any doubt whatever. But in such cases the practical difference of the two systems of correction would have been insensible. When the corrected screen readings were converted into time, and again differenced, we were able, almost by inspection, to obtain corresponding values of the velocity of the shot and of the resistance of the air, just at the instant when the shot passed any of the screens. In this manner we obtained several corresponding values of velocity and resistance for each good round fired. As it was found impossible to express the resistance of the air

in terms of the velocity by any simple formula, the resistance has been expressed in terms of the cube of the velocity in connection with a *variable* coefficient. In considering the motion of a shot it will be necessary from time to time to change the coefficient so as to keep it in accordance with the velocity of the shot. The law of the cube of the velocity has been chosen on account of the simplicity of the formulæ to which it gives rise.

52. The experiments were carried out with guns of 3, 5, 7, and 9-inch calibres, for which the following elongated shot were manufactured with great care in the Royal Arsenal, Woolwich; namely, shot 2·92 inches in diameter, weighing 12, 9, and 6 lbs. for the 3-inch gun; shot 4·92 inches in diameter, weighing 47·68 and 23·84 lbs. for the 5-inch gun; shot 6·92 inches in diameter weighing 122·3 and 61·15 lbs. for the 7-inch gun; and shot 8·92 inches in diameter weighing 250 and 125 lbs. for the 9-inch gun. The charges used in each gun were generally the one-sixth, the one-eighth, and the one-twelfth of the weight of the solid shot. The shot had *similar* external forms, the heads being of the ogival form struck with radii of one diameter and a half. The resistance of the air was found to vary as the square of the diameter of the projectile, but when the resistance of the air to a given projectile was expressed under the form $2b \times (\text{velocity})^3$, it was found that $2b$ attained a maximum value for a velocity of about 1200 feet per second, and consequently decreased for higher and lower velocities. The numerical values of b were determined experimentally for ogival-headed elongated shot and other kindred forms, for all velocities between 900 and 1700 feet per second.* These coefficients in a convenient form will be found in Table I. Afterwards guns of the same calibres were used to fire solid and hollow spherical shot, in order to determine the coefficients for the cubic law of resistance to spherical shot corresponding to all velocities between 850 and 2150 feet per second.† These coefficients are given in a convenient form in Table II.

53. The following examples are given as illustrations of the great utility of differencing when systematic experiments or independent calculations are being made. Suppose that

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* *Reports, &c.*, p. 152. † *Reports, &c.*, p. 114.

the following logarithms of numbers have been independently calculated, and that the calculator wished to test the accuracy of his work.

Nos.	Calculated logarithms.	Δ_1	Δ_2	Corrections.	Corrected logarithms.	Δ_1	Δ_2
1280	107210	+ 3380			107210	+ 3380	
1290	110590	+ 3353	− 27		110590	+ 3353	− 27
1300	113943	+ 33**1**8	− **3**5	+ 10	113943	+ 33**2**8	− **2**5
1310	1172**61**	+ 33**1**3	− **0**5	− 20	1172**7**1	+ 33**0**3	− **2**5
1320	120574	+ 3278	− **3**5	+ 10	120574	+ 3278	− **2**5
1330	123852	+ 325**4**	− 2**4**	− 1	123852	+ 325**3**	− 2**5**
1340	12710**6**	+ 322**8**	− 2**6**	+ 2	12710**5**	+ 322**9**	− 2**4**
1350	130334	+ 3205	− **23**	− 1	130334	+ 3205	− 2**4**
1360	133539	+ 3182	− 23		133539	+ 3182	− 23
1370	136721				136721		

The difference of type indicates the erroneous figures in one place and their corrections in the other. Tables of the squares, cubes, &c., of numbers have respectively their second, third, &c. differences constant, thus

No.	Squares.	Δ_1	Δ_2	Cubes.	Δ_1	Δ_2	Δ_3
1	1	+ 3		1	+ 7		
2	4	+ 5	+ 2	8	+ 19	+ 12	+ 6
3	9	+ 7	+ 2	27	+ 37	+ 18	+ 6
4	16	+ 9	+ 2	64	+ 61	+ 24	+ 6
5	25	+ 11	+ 2	125	+ 91	+ 30	+ 6
6	36	+ 13	+ 2	216	+ 127	+ 36	+ 6
7	49	+ 15	+ 2	343	+ 169	+ 42	+ 6
8	64	+ 17	+ 2	512	+ 217	+ 48	+ 6
9	81	+ 19	+ 2	729	+ 271	+ 54	+ 6
10	100	+ 21	+ 2	1000	+ 331	+ 60	+ 6
11	121	+ 23	+ 2	1331	+ 397	+ 66	+ 6
12	144		+ 2	1728			
	&c.			&c.			

As the final differences are here constant, we could go on and calculate complete tables of squares and cubes of integers. In the former case adding 2 to 17 we have 19, and adding 19 to 81 we get 100, the square of 10 and so on; and in the latter case adding 6 to 48 we get 54, and 54 to 217 we get 271, and adding 271 to 729 we get 1000, the cube of 10. Difference machines have been constructed to work on this principle. In the same way we may calculate formulæ of the form $u = a + bx + cx^2$, where the first order of differences Δ_1, would be $b+2cx$, and the second, Δ_2, would be constant and $=2c$. If $u=a+bx+cx^2+dx^3$, then the column of the third order of differences Δ_3 would be constant and $=+6d$. In the generality of tables, no order of differences would be absolutely constant, but the final order used would in general change very slowly, as in the above example taken from a table of logarithms.

54. We now proceed to shew how the first and second differential coefficients may be expressed in terms of the successive differences.

By finite differences we have

$$\Delta u_x = u_{x+l} - u_x,$$

or $u_{x+l} = u_x + \Delta u_x,$

$$u_{x+2l} = u_{x+l} + \Delta u_{x+l} = u_x + \Delta u_x + \Delta(u_x + \Delta u_x) = u_x + 2\Delta u_x + \Delta^2 u_x,$$

$$u_{x+3l} = u_x + 3\Delta u_x + 3\Delta^2 u_x + \Delta^3 u_x,$$

&c.

And generally

$$u_{x+nl} = u_x + n\Delta u_x + \frac{n.(n-1)}{1.2}\Delta^2 u_x + \frac{n.(n-1).(n-2)}{1.2.3}\Delta^3 u_x + \&c.,$$

$$= u_x + n\{\Delta u_x - \tfrac{1}{2}\Delta^2 u_x + \tfrac{1}{3}\Delta^3 u_x - \tfrac{1}{4}\Delta^4 u_x + \tfrac{1}{5}\Delta^5 u_x - \tfrac{1}{6}\Delta^6 u_x + \&c.\},$$

$$+ n^2\{\tfrac{1}{2}\Delta^2 u_x - \tfrac{1}{2}\Delta^3 u_x + \tfrac{11}{24}\Delta^4 u_x - \tfrac{10}{24}\Delta^5 u_x + \tfrac{137}{360}\Delta^6 u_x + \&c.\},$$

$$+ \qquad \&c.$$

Expanding now u_{x+nl} by Taylor's Theorem, we have

$$u_{x+nl} = u_x + \frac{du_x}{dx}\frac{nl}{1} + \frac{d^2u_x}{dx^2}\frac{n^2l^2}{1.2} + \frac{d^3u_x}{dx^3}\frac{n^3l^3}{1.2.3} + \&c.,$$

and equating the coefficients of the first and second powers of n in the two expansions of u_{x+nl} we have

$$l\frac{du_x}{dx} = \Delta u_x - \tfrac{1}{2}\Delta^2 u_x + \tfrac{1}{3}\Delta^3 u_x - \tfrac{1}{4}\Delta^4 u_x + \tfrac{1}{5}\Delta^5 u_x - \tfrac{1}{6}\Delta^6 u_x + \&c.,$$

$$l^2\frac{d^2u_x}{dx^2} = \Delta^2 u_x - \Delta^3 u_x + \tfrac{11}{12}\Delta^4 u_x - \tfrac{10}{12}\Delta^5 u_x + \tfrac{137}{180}\Delta^6 u_x - \&c.$$

The following scheme will explain the meanings of the several terms:

$$
\begin{array}{lllllll}
u_{x-4l} & & & & & & \\
 & +\Delta u_{x-4l} & & & & & \\
u_{x-3l} & & +\Delta^2 u_{x-4l} & & & & \\
 & +\Delta u_{x-3l} & & +\Delta^3 u_{x-4l} & & & \\
u_{x-2l} & & +\Delta^2 u_{x-3l} & & +\Delta^4 u_{x-4l} & & \\
 & +\Delta u_{x-2l} & & +\Delta^3 u_{x-3l} & & +\Delta^5 u_{x-4l} & \\
u_{x-l} & & +\Delta^2 u_{x-2l} & & +\Delta^4 u_{x-3l} & & +\Delta^6 u_{x-4l} \\
 & +\Delta u_{x-l} & & +\Delta^3 u_{x-2l} & & +\Delta^5 u_{x-3l} & \\
u_{x} & & +\Delta^2 u_{x-l} & & +\Delta^4 u_{x-2l} & & +\Delta^6 u_{x-3l} \\
 & +\Delta u_{x} & & +\Delta^3 u_{x-l} & & +\Delta^5 u_{x-2l} & \\
u_{x+l} & & +\Delta^2 u_{x} & & +\Delta^4 u_{x-l} & & +\Delta^6 u_{x-2l} \\
 & +\Delta u_{x+l} & & +\Delta^3 u_{x} & & +\Delta^5 u_{x-l} & \\
u_{x+2l} & & +\Delta^2 u_{x+l} & & +\Delta^4 u_{x} & & +\Delta^6 u_{x-l} \\
 & +\Delta u_{x+2l} & & +\Delta^3 u_{x+l} & & +\Delta^5 u_{x} & \\
u_{x+3l} & & +\Delta^2 u_{x+2l} & & +\Delta^4 u_{x+l} & & \\
 & +\Delta u_{x+3l} & & +\Delta^3 u_{x+2l} & & & \\
u_{x+4l} & & +\Delta^2 u_{x+3l} & & & & \\
 & +\Delta u_{x+4l} & & & & & \\
u_{x+5l} & & & & & &
\end{array}
$$

$$
\begin{array}{lllll}
\text{Now} & u_x & = & u_{x-l} & +\Delta u_{x-l} \\
\text{therefore} & \Delta^2 u_x & = & \Delta^2 u_{x-l} & +\Delta^3 u_{x-l} \\
\text{and} & -\Delta^3 u_x & = & -\Delta^3 u_{x-l} & -\Delta^4 u_{x-l} \\
 & +\frac{11}{12}\Delta^4 u_x & = & +\frac{11}{12}\Delta^4 u_{x-l} & +\frac{11}{12}\Delta^5 u_{x-l} \\
 & -\frac{10}{12}\Delta^5 u_x & = & -\frac{10}{12}\Delta^5 u_{x-l} & -\frac{10}{12}\Delta^6 u_{x-l} \\
 & +\frac{137}{180}\Delta^6 u_x & = & +\frac{137}{180}\Delta^6 u_{x-l} & +\frac{137}{180}\Delta^7 u_{x-l} \\
 & & & \&c. & \&c.
\end{array}
$$

Taking the sum we find

$$
l^2 \frac{d^2 u_x}{dx^2} = \Delta^2 u_{x-l} - \tfrac{1}{12}\Delta^4 u_{x-l} + \tfrac{1}{12}\Delta^5 u_{x-l} - \tfrac{13}{180}\Delta^6 u_{x-l} + \&c.,
$$

$$
= \Delta^2 u_{x-l} - \tfrac{1}{12}\Delta^4 u_{x-2l} + \tfrac{1}{90}\Delta^6 u_{x-3l} - \&c.
$$

Let s be the distance the ball has moved from some fixed point to a screen at a time t_s, l the distance between successive screens, and t_{s-2l}, t_{s-l}, t_s, t_{s+l}, t_{s+2l}, &c. the observed times of the shot passing successive screens; then we shall have

$$
l \frac{dt_s}{ds} = \Delta t_s - \tfrac{1}{2}\Delta^2 t_s + \tfrac{1}{3}\Delta^3 t_s - \tfrac{1}{4}\Delta^4 t_s + \tfrac{1}{5}\Delta^5 t_s - \tfrac{1}{6}\Delta^6 t_s + \&c.,
$$

or $\frac{ds}{dt_s}$ = velocity which the ball had at the distance s,

$$= v_s = \frac{l}{\Delta t_s - \frac{1}{2}\Delta^2 t_s + \frac{1}{3}\Delta^3 t_s - \frac{1}{4}\Delta^4 t_s + \frac{1}{5}\Delta^5 t_s - \frac{1}{6}\Delta^6 t_s + \&c.} \ldots (1),$$

supposing v_s to denote the velocity, and f_s the retarding force at distance s,

$$l^2 \frac{d^2 t_s}{ds^2} = \Delta^2 t_{s-l} - \frac{1}{12}\Delta^4 t_{s-2l} + \frac{1}{90}\Delta^6 t_{s-3l} - \&c.$$

But $$f_s = \frac{d^2 s}{dt_s^2} = -\frac{d^2 t_s}{ds^2}\left(\frac{ds}{dt_s}\right)^3$$

$$= -\frac{v_s^3}{l^2}\left(\Delta^2 t_{s-l} - \frac{1}{12}\Delta^4 t_{s-2l} + \frac{12}{90}\Delta^6 t_{s-3l} - \&c.\right) \ldots (2).$$

The use of formulæ (1) and (2) will be best understood from their application to numerical examples.

55. Hollow elongated shot weighing 23·84 lbs. 5-inch gun. Diameter of shot 4·92 inches.

The readings of the seconds and their corrections were as follows:

Seconds.	Reading.	Correction applied.	Corrected Reading.	Δ_1	Δ_2	Δ_3
1	25·90	− ·001 =	25·899			
				+ 23·893		
2	49·79	+ ·002 =	49·792		− 48	
				+ 23·845		− 3
3	73·64	− ·003 =	73·637		− 51	
				+ 23·794		− 3
4	97·43	+ ·001 =	97·431		− 54	
				+ 23·740		
5	121·17	+ ·001 =	121·171			

It was usual to read off a few seconds beyond the limits of the screen records, in order to determine the exact motion of the cylinder. In this case the screen records extended from 74 to 100. Hence it was sufficient to form a complete time-table extending from 3·0 to 4·5 seconds. By interpolation we can now find where the half-second beats would have been marked, just as well as if the clock had given a record every half second. The result is

Seconds.	Divisions.	Δ_1	Δ_2
3·0	73·637		
		+ 11·904	
3·5	85·541		− 14
		+ 11·890	
4·0	97·431		− 13
		+ 11·877	
4·5	109·308		− 14
		+ 11·863	
5·0	121·171		

By a further interpolation, we find the places of every division of the seconds into tenths, so far as is required for the reduction of the experiment.

Seconds.	Divisions.	Δ_1	Seconds.	Divisions.	Δ_1
3·0	73·637	+ 2·382	3·8	92·677	+ 2·377
3·1	76·019	+ 2·381	3·9	95·054	+ 2·377
3·2	78·400	+ 2·381	4·0	97·431	+ 2·377
3·3	80·781	+ 2·380	4·1	99·808	+ 2·376
3·4	83·161	+ 2·380	4·2	102·184	+ 2·375
3·5	85·541	+ 2·379	4·3	104·559	+ 2·375
3·6	87·920	+ 2·379	4·4	106·934	+ 2·374
3·7	90·299	2·378	4·5	109·308	

Here it is plain from the column Δ_1 which gives the lengths of the scale corresponding to successive tenths of seconds, that for fractions of a second less than one-tenth of a second, the common rule of proportional parts will apply. This is the time-table to be used in converting the screen readings, after the application of slight corrections, into time.

Screens.	Reading.	Correction.		Corrected Reading.	Δ_1	Δ_2
1	74·89	− ·001	=	74·889	+ 2·596	
2	77·48	+ ·005	=	77·485	+ 2·653	+ 57
3	80·14	− ·002	=	80·138	+ 2·710	+ 57
4	82·85	− ·002	=	82·848	+ 2·768	+ 58
5	85·61	+ ·006	=	85·616	+ 2·826	+ 58
6	88·44	+ ·002	=	88·442	+ 2·883	+ 57
7	91·33	− ·005	=	91·325	+ 2·941	+ 58
8	94·26	+ ·006	=	94·266	+ 2·999	+ 58
9	97·27	− ·005	=	97·265	+ 3·056	+ 57
10	100·32	+ ·001	=	100·321		

The reading for the first screen was	74·889
The reading for 3·0 seconds was .	73·637
Difference	1·252

The length of the tenth of a second was 2·382, so that the shot passed the first screen at $3{\cdot}0 + \frac{1}{10}\,\frac{1{\cdot}252}{2{\cdot}382} = 3{\cdot}0526$ seconds. And in the same manner, the other corrected screen readings were converted into seconds. The result will be found to be

Screen,	passed at, seconds.	Δ_1	Δ_2
1	3·0526	+ 1090	
2	3·1616	+ 1114	+ 24
3	3·2730	+ 1138	+ 24
4	3·3868	+ 1163	+ 25
5	3·5031	+ 1188	+ 25
6	3·6219	+ 1213	+ 25
7	3·7432	+ 1337	+ 24
8	3·8669	+ 1261	+ 24
9	3·9930	+ 1286	+ 25
10	4·1216		

The screens were 150 feet apart $= l$. The velocity v_5 at the fifth screen

$$= \frac{150}{\Delta t_5 - \frac{1}{2}\Delta^2 t_5} = \frac{150}{\cdot 1188 - \frac{1}{2}\cdot 0025} = \frac{300}{\cdot 2351} = 1276\cdot 1 f\text{-}s.$$

Also the retarding force at the fifth screen

$$= f_5 = -\frac{v_5^{\,3}}{l^2}\left(\Delta^2 t_5 - \tfrac{1}{12}\Delta^4 t_4\right)$$

$$= -\,v_5^{\,3} \times \frac{\cdot 0025}{(150)^2} = -\,2bv^3.$$

And putting it under the form used in Table I.,

$$K_v = 2b\,(1000)^3\,\frac{w}{d^2} = (1000)^3.\,\frac{.0025}{(150)^2}\cdot\frac{23\cdot 84}{(4.92)^2} = 109\cdot 4.$$

But this experiment was made when the density of the air was 1·0076, so reducing 109·4 accordingly, we get

$$2b\,(1000)^3\,\frac{w}{d^2} = 109\cdot 4 - 0\cdot 8 = 108\cdot 6.$$

The tabular number corresponding to a velocity 1275 *f-s* is given 108·4 in Table I. It is manifest that, as the column Δ_2 is nearly constant in this experiment, the value of the coefficient $2b$ of the cube of the velocity is also nearly constant; or, for the range of velocity obtained in this experiment, the retarding force varies very nearly as the cube of the velocity.

56. From what has been said in Art. 53 it appears that when a function of the form $a' + as + bs^2$ is tabulated for successive integral values of s, the second differences of those quantities will be constant and equal to $2b$.

The experiments of 1865 and 1866 gave the second differences of the times of passing the equi-distant screens $\Delta^2 t$ nearly constant, as in the numerical example just given, because they were made with velocities near those which gave a maximum value of $2b$. It was therefore inferred that if the space s was described in the time t, then t might be expressed in terms of s as follows:

or $$t = as + bs^2,$$

and differentiating $$\frac{ds}{dt} = v = \frac{1}{a + 2bs},$$

and $$\frac{d^2s}{dt^2} = f = -\frac{2b}{(a+2bs)^2} \cdot \frac{ds}{dt} = -2bv^3 \propto v^3,$$

or the resistance of the air varied approximately as the cube of the velocity for the particular velocities obtained in these experiments.

57. We will now pass to an experiment made with a 6·92-inch spherical shot, weighing 44·094 lbs., fired from a 7-inch gun. The process for finding by experiment the exact time at which the shot passed each screen was precisely the same as before.

Screens,	passed at, seconds.	Δ_1	Δ_2	Δ_3
1	2·90068	+ 8431	+ 306	+ 10
2	2·98499	+ 8737	+ 316	+ 10
3	3·07236	+ 9053	+ 326	+ 10
4	3·16289	+ 9379	+ 336	+ 10
5	3·25668	+ 9715	+ 346	+ 10
6	3·35383	+ 10061	+ 356	+ 11
7	3·45444	+ 10417	+ 367	+ 11
8	3·55861	+ 10784	+ 378	
9	3·66645	+ 11162		
10	3·77807			

Here
$$v_3 = \frac{l}{\Delta t_3 - \frac{1}{2}\Delta^2 t_3 + \frac{1}{3}\Delta^3 t_3}$$
$$= \frac{150}{\cdot 09053 - \frac{1}{2}\cdot 00326 + \frac{1}{3}\cdot 00010}$$
$$= 1686\cdot 7 \textit{ f-s.}$$
$$f_3 = -\frac{v_3^3}{l^3}(\Delta^2 t_3 - \Delta^3 t_2)$$
$$= -\frac{v_3^3}{(150)^3}(\cdot 00316 - \cdot 00010) = -2bv_3^3;$$
therefore
$$K_v = (1000)^3\, 2b\,\frac{w}{d^2} = \frac{(1000)^3 \times \cdot 00306}{(150)^3} \times \frac{44\cdot 094}{(6\cdot 92)^2} \times \frac{1}{1\cdot 0441}$$
$$= 120\cdot 0,$$
including a correction for the density of the air. The tabular value of K_v for a spherical shot corresponding to a velocity of 1690*f-s* is 121·4. In the last example the column headed Δ^2 is far from being constant. Several coefficients corresponding to velocities between 1700*f-s*, and 1400*f-s* were found from this single round.

The reductions of the coefficients of resistance given in Tables I. and II. were made on the supposition that the weight of a cubic foot of dry air was 530·6 grains, which corresponds to a height of 30 inches of the barometer and a temperature of 65°.5 F., and not of 62° F. as stated at page 21 of *Reports, &c.*

CHAPTER IV.

ON THE MOTION OF A PROJECTILE IN A RESISTING MEDIUM.

58. The history of the mathematical investigation of the path described by a projectile in a resisting medium, which has been made use of in this treatise, is somewhat curious. About the time when Newton flourished it was common for the leading mathematicians in England and on the Continent to propose difficult problems by way of challenge to one another. It was of course supposed that any mathematician, who proposed a problem, knew how to solve it. After this manner Keill proposed the following question to John Bernoulli in 1718: "Invenire curvam, quam projectile describit "in aëre, pro simplicissima suppositione gravitatis atque "medii densitatis uniformis, resistentiæ vero in duplicata "ratione velocitatis."* Bernoulli received the challenge early in February, 1718, and in a short time obtained a solution, not only of the problem where the resistance varies as the *square* of the velocity, which was proposed, but also for a resistance varying according to *any power* of the velocity. Before, however, he published his solution, he deemed it right and proper to propose the same problem to his opponent Keill. This was done in the following May. Bernoulli gave Keill till September to declare whether he could solve his own problem, adding that, if at the expiration of the specified time no solution was received, silence would be taken as a tacit confession of incompetency. At the intercession of the friend through whom these communications passed, the time given was extended to November, but no solution was furnished by Keill. Bernoulli goes on to argue that Keill in his difficulty would undoubtedly seek assistance from all the English mathematicians. He therefore felt persuaded that if any one in England had been able to solve the problem, a solution would have been produced within the prescribed time. After this, Bernoulli furnished the following statement of his result to a friend, in which the resistance of the air is supposed to vary as the $2n^{\text{th}}$ power

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* *Opera*, II., p. 396.

of the velocity: "Assumta indeterminata z construatur area "$\int(aa+zz)^{n-\frac{1}{2}}dz$ quæ vocetur Z; sint autem coordinatæ curvæ "quæsitæ x et y. Fiat $x=\int(zdzZ^{-1:n})$ et $y=\int(adzZ^{-1:n})$. "Dico curvam quæ inde oritur esse quæsitam."*

Bernoulli published his analysis in 1721,† which he described as no more than a chain of equalities deduced from the general formula for the determination of resistances which he had published in 1713. The following is a sketch of his method of treating the problem.‡

Let the plane xy be the vertical plane in which the trajectory is supposed to lie, the axis of x being in the intersection of this plane and the horizontal plane through the point of projection O, fig. 7. The force of gravity g is supposed to be constant and always to act in a direction parallel to the axis of y, which is vertical. The point of projection is the origin. If t be the time and R the retarding force of the air acting in a tangent to the trajectory at the point x, y, then Bernoulli begins with the equation $R=-g\left\{\frac{dy}{ds}+\frac{1}{2}\frac{dq}{ds}\right\}$ where $2q$ is the vertical chord of curvature at the point x,y, a demonstration of which he had published in 1713.§ This may be shewn to be true as follows, ρ denoting the radius of curvature:

$$\frac{v^2}{\rho}=g\cos\theta,\ \text{or}\ \left(\frac{ds}{dt}\right)^2=g\rho\cos\theta=gq,$$

and differentiating

$$\frac{d^2s}{dt^2}=\frac{g}{2}\frac{dq}{ds}=\text{also}-R-g\sin\theta=-R-g\frac{dy}{ds};$$

therefore $$R=-g\frac{dy}{ds}-\frac{g}{2}\frac{dq}{ds}=-g\left(\frac{dy}{ds}+\frac{1}{2}\frac{dq}{ds}\right).$$

Now $$q=-\frac{1+\left(\frac{dy}{dx}\right)^2}{\frac{d^2y}{dx^2}}=-\frac{\left(\frac{ds}{dx}\right)^2}{\frac{d^2y}{dx^2}},$$

$$\frac{dq}{dx}=-2\frac{dy}{dx}+\left\{1+\left(\frac{dy}{dx}\right)^2\right\}\frac{\frac{d^3y}{dx^3}}{\left(\frac{d^2y}{dx^2}\right)^2},$$

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* *Opera*, II., p. 399.

† *Acta. Erudit. Lips.*, 1721, Maj., p. 228.

‡ *Opera*, II., p. 513.

§ *Acta. Erudit. Lips.*, 1713, p. 77; *Opera*, I., 533.

or $$\frac{dq}{ds} = -2\frac{dy}{ds} + \frac{ds}{dx}\frac{\frac{d^3y}{dx^3}}{\left(\frac{d^2y}{dx^2}\right)^2};$$

therefore $$R = -\frac{g}{2}\left(2\frac{dy}{ds} + \frac{dq}{ds}\right)$$
$$= -\frac{g}{2}\frac{\frac{ds}{dx}\frac{d^3y}{dx^3}}{\left(\frac{d^2y}{dx^2}\right)^2}.$$

But as R varies as the $2n^{\text{th}}$ power of the velocity, we have

$$R = kv^{2n} = k(gq)^n = k\left\{-g\frac{\left(\frac{ds}{dx}\right)^2}{\frac{d^2y}{dx^2}}\right\}^n.$$

And equating the two values of R, we find

$$-\frac{g}{2}\frac{\frac{ds}{dx}\frac{d^3y}{dx^3}}{\left(\frac{d^2y}{dx^2}\right)^2} = k\left\{-g\frac{\left(\frac{ds}{dx}\right)^2}{\frac{d^2y}{dx^2}}\right\}^n,$$

or $$k(-g)^{n-1}\left(\frac{ds}{dx}\right)^{2n-1} = \frac{1}{2}\left(\frac{d^2y}{dx^2}\right)^{n-2}\frac{d^3y}{dx^3}.$$

Let now $$\frac{dy}{dx} = \frac{z}{a},$$

then $$\left(\frac{ds}{dx}\right)^{2n-1} = \frac{1}{a^{2n-1}}(a^2+z^2)^{\frac{2n-1}{2}}.$$

Also $$\frac{d^2y}{dx^2} = \frac{1}{a}\frac{dz}{dx}, \text{ and } \frac{d^3y}{dx^3} = \frac{1}{a}\frac{d^2z}{dx^2}.$$

By substitution, we have

$$2k(-g)^{n-1}\frac{1}{a^{2n-1}}(a^2+z^2)^{\frac{2n-1}{2}}\frac{dz}{dx} = \frac{1}{a^{n-1}}\left(\frac{dz}{dx}\right)^{n-1}\frac{d^2z}{dx^2},$$

and putting Z for $\int(a^2+z^2)^{\frac{2n-1}{2}}\frac{dz}{dx}$, and integrating, we have

$$2nk\left(-\frac{g}{a}\right)^n Z = -g\left(\frac{dz}{dx}\right)^n;$$

therefore $$dx = -\frac{a}{g}\left(\frac{g}{k}\right)^{\frac{1}{n}} \frac{dz}{(-2nZ)^{\frac{1}{n}}},$$

or $$x = -\frac{a}{g}\left(\frac{g}{k}\right)^{\frac{1}{n}} \int \frac{dz}{(-2nZ)^{\frac{1}{n}}}.$$

Also $$dy = \frac{z}{a}\,dx = -\frac{1}{g}\left(\frac{g}{k}\right)^{\frac{1}{n}} \frac{zdz}{(-2nZ)^{\frac{1}{n}}};$$

therefore $$y = -\frac{1}{g}\left(\frac{g}{k}\right)^{\frac{1}{n}} \int \frac{zdz}{(-2nZ)^{\frac{1}{n}}}.$$

59. Suppose we apply these results to the particular case where the resistance varies as the cube of the velocity, we have $2n = 3$. Let u_0 be the velocity of the shot at the vertex of the trajectory. At this point $\frac{dy}{dx} = 0$; therefore $z = 0$, and $\frac{d^2y}{dx^2} = \frac{1}{a}\frac{dz}{dx}$. But

$$\begin{aligned} u_0^2 &= g \times \text{radius of curvature at the vertex} \\ &= -g \frac{a}{\frac{dz}{dx}}, \end{aligned}$$

or $$\frac{dz}{dx} = -\frac{ga}{u_0^2} \text{ at the vertex.}$$

And $$\begin{aligned} Z &= \int (a^2 + z^2)^{\frac{2n-1}{2}} dz \\ &= \int (a^2 + z^2)\, dz \\ &= C + a^2 z + \frac{z^3}{3}. \end{aligned}$$

And since $$2nk\left(-\frac{g}{a}\right)^n Z = -g\left(\frac{dz}{dx}\right)^n,$$

we have $$3k\left(-\frac{g}{a}\right)^{\frac{3}{2}}\left(C + a^2 z + \frac{z^3}{3}\right) = -g\left(\frac{dz}{dx}\right)^{\frac{3}{2}};$$

and at the vertex $$3k\left(-\frac{g}{a}\right)^{\frac{3}{2}} C = -g\left(-\frac{ga}{u_0^2}\right)^{\frac{3}{2}},$$

or $$3C = -\frac{g}{k}\frac{a^3}{u_0^3}, \text{ which determines } C.$$

Also $$\frac{dy}{dx} = \tan\theta = p = \frac{z}{a},$$

and $$dz = adp;$$

therefore since $$3k\left(-\frac{g}{a}\right)^{\frac{3}{2}}\left(C + a^2z + \frac{z^3}{3}\right) = -g\left(\frac{adp}{dx}\right)^{\frac{3}{2}},$$

$$dx = -\frac{u_0^2}{g}\frac{dp}{\left\{1 - \frac{ku_0^3}{g}(3p + p^3)\right\}^{\frac{2}{3}}},$$

or $$x = -\frac{u_0^2}{g}\int\frac{dp}{\left\{1 - \frac{ku_0^3}{g}(3p + p^3)\right\}^{\frac{2}{3}}},$$

and $$y = -\frac{u_0^2}{g}\int\frac{pdp}{\left\{1 - \frac{ku_0^3}{g}(3p + p^2)\right\}^{2}}.$$

Respecting this solution Montucla has remarked, "Mais "la solution de ce grand géomètre ne pouvoit être utile pour "la pratique, parce que l'aire de la courbe ne pouvant la "plupart du temps être exprimée en termes finis, il est "comme impossible, au moins d'après l'analyse actuelle, "d'en tirer la valeur des inconnues; si l'on y parvenoit on "n'arriveroit qu'à des valeurs si compliquées qu'elles ne "seroient d'acun usage."* The case where $2n = 3$ is perhaps the simplest of all, and yet the only way to render Bernoulli's results practically useful, was to calculate by quadratures tables of the values of the above integrals for all possible practical values of p and $\frac{ku_0^3}{g}$ or γ, so numerous that all intermediate values might be obtained from the tables either by a simple interpolation or by proportional parts.

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* Professor Adams communicated to me the above expressions for x and y and an additional one for the time in a letter dated Nov. 13, 1866, when the few ballistic experiments I had then made seemed to indicate a cubic law of resistance. Professor Adams at the same time remarked that the "form of solution was "worked out by my own investigations, but on looking into the history of the "problem, I find that an equivalent process was given long ago by John Bernoulli."

60. Explanation of symbols used.

g denotes the accelerating force of gravity and equals 32·191 feet per second in the latitude of Greenwich,

w the weight of the shot in pounds,

d the diameter of the shot in inches,

$2bv^3$ the retarding effect of the air for a velocity v feet per second.

$K = 2b \times \frac{w}{d^2} \times (1000)^3$.

x, y are the horizontal and vertical coordinates of the centre of gravity of the shot at time t, the origin being at the point of projection.

v denotes the velocity, and u the horizontal velocity of the shot at the point (x, y).

ϕ is the inclination to the horizon of the tangent to the trajectory at the point (x, y).

v_ϕ denotes the velocity of the shot in the *ascending* branch when moving in a direction inclined at an angle ϕ to the horizon, and u_ϕ the corresponding horizontal velocity, so that $u_\phi = v_\phi \cos\phi$. v'_ϕ and u'_ϕ denote corresponding quantities in the *descending* branch.

$P_\phi = 3 \tan\phi + \tan^3\phi$.

${}_\alpha x_\beta$ and ${}_\alpha y_\beta$ denote the differences of the coordinates of two points where the trajectory is inclined at angles α, β to the horizon; thus in fig. 9, ${}_\alpha x_\beta = An$, and ${}_\alpha y_\beta = Bn$; and in like manner ${}_\alpha t_\beta$ would denote the time of describing AB.

61. Suppose a body projected in a direction inclined at an angle α to the horizon, to be acted upon by the force of gravity g acting in parallel lines, and by a retarding force $2b \times (\text{velocity})^3$ acting at every point in the direction of the tangent to the trajectory of the body at that point, then there will be no force tending to draw the projectile out of the vertical plane of projection. Fig. 8, let O the point of projection be the origin, and let the axes of x and y respectively be horizontal and vertical in the plane of the projectile's motion. Also let x, y be the coordinates of the centre of gravity of the shot at time t.

The equations of motion are

$$\frac{d^2x}{dt^2} = -2b\left(\frac{ds}{dt}\right)^3 \frac{dx}{ds} = -2b\left(\frac{ds}{dt}\right)^2 \frac{dx}{dt},$$

and $$\frac{d^2y}{dt^2} = -2b\left(\frac{ds}{dt}\right)^3 \frac{dy}{ds} - g = -2b\left(\frac{ds}{dt}\right)^2 \frac{dy}{dt} - g;$$

therefore $$\frac{d^2y}{dt^2}\frac{dx}{dt}-\frac{dy}{dt}\frac{d^2x}{dt^2}=-g\frac{dx}{dt}.$$

Let $$p=\frac{dy}{dx}=\frac{\frac{dy}{dt}}{\frac{dx}{dt}},$$

then $$\frac{dp}{dt}=\frac{\frac{dx}{dt}\frac{d^2y}{dt^2}-\frac{dy}{dt}\frac{d^2x}{dt^2}}{\left(\frac{dx}{dt}\right)^2}=-\frac{g}{\frac{dx}{dt}},$$

or $$\frac{dp}{dt}\cdot\frac{dx}{dt}=-g \;\dots\dots\dots\dots\dots\dots\; (1).$$

62. Again

$$\frac{d^2x}{dt^2}=-2b\left(\frac{ds}{dt}\right)^2\frac{dx}{dt}=-2b\left\{1+\left(\frac{dy}{dx}\right)^2\right\}\left(\frac{dx}{dt}\right)^3$$

$$=-2b\,(1+p^2)\left(\frac{dx}{dt}\right)^3;$$

therefore

$$\frac{\frac{d^2x}{dt^2}}{\left(\frac{dx}{dt}\right)^4}=-2b\,(1+p^2)\frac{1}{\frac{dx}{dt}}=\frac{2b}{g}(1+p^2)\frac{dp}{dt},$$

or $$-\frac{1}{3}\frac{1}{\left(\frac{dx}{dt}\right)^3}=C+\frac{2b}{g}\left(p+\frac{p^3}{3}\right).$$

At the vertex let the horizontal velocity $\frac{dx}{dt}=u_0$, when $p=0$; therefore

$$-\frac{1}{3}\frac{1}{u_0^3}=C,$$

and $$-\frac{1}{3}\frac{1}{\left(\frac{dx}{dt}\right)^3}=-\frac{1}{3u_0^3}+\frac{2b}{g}\left(p+\frac{p^3}{3}\right),$$

or if $u = \frac{dx}{dt}$ = the horizontal velocity of the projectile at the point (x, y), then

$$\frac{1}{u^3} = \frac{1}{u_0^3} - \frac{2b}{g}(3p + p^3) \text{ .... (2).}$$

Substituting for $\frac{1}{u}$ or $\frac{dt}{dx}$ in the last equation its value $-\frac{1}{g}\frac{dp}{dt}$ given by (1), we have

$$-\left(\frac{1}{g}\frac{dp}{dt}\right)^3 = \frac{1}{u_0^3} - \frac{2b}{g}(3p + p^3),$$

or
$$\frac{dp}{dt} = -\frac{g}{u_0}\left\{1 - \frac{2bu_0^3}{g}(3p + p^3)\right\}^{\frac{1}{3}},$$

or
$$t = -\frac{u_0}{g}\,{}^{p}\!\!\int^{p'} \frac{dp}{\{1 - \gamma(3p + p^3)\}^{\frac{1}{3}}} \text{ .... (3),}$$

if $\gamma = \frac{2bu_0^3}{g} = \frac{2bMu_0^3}{Mg}$

$$= \frac{\text{resistance of the air at the vertex of trajectory}}{\text{weight of the shot}}.$$

By equation (1)

$$\frac{dp}{dt}\frac{dx}{dt} = -g, \text{ or } \frac{dp}{dx}\left(\frac{dx}{dt}\right)^2 = -g;$$

therefore $\frac{dx}{dp} = -\frac{1}{g}\left(\frac{dx}{dt}\right)^2 = -\frac{1}{g}\left\{\frac{1}{u_0^3} - \frac{2b}{g}(3p + p^3)\right\}^{-\frac{2}{3}}$

$$= -\frac{u_0^2}{g}\{1 - \gamma(3p + p^3)\}^{-\frac{2}{3}}$$

or
$$x = -\frac{u_0^2}{g}\,{}^{p}\!\!\int^{p'} \frac{dp}{\{1 - \gamma(3p + p^3)\}^{\frac{2}{3}}} \text{ .... (4).}$$

Again, $\frac{dy}{dx} = p$; therefore $\frac{dy}{dp} = p\frac{dx}{dp}$

$$= -\frac{u_0^2}{g}\frac{pdp}{\{1 - \gamma(3p + p^3)\}^{\frac{2}{3}}}$$

or
$$y = -\frac{u_0^2}{g}\,{}^{p}\!\!\int^{p'} \frac{pdp}{\{1 - \gamma(3p + p^3)\}^{\frac{2}{3}}} \text{ .... (5).}$$

63. If $\tan\phi = p$ and $\tan\phi' = p'$, then

$$dp = \sec^2\phi d\phi = (1+p^2)\, d\phi,$$

and the above equations (3), (4) and (5) take the forms

$$t = -\frac{u_0}{g}\, {}^{\phi}\!\int^{\phi'} \frac{(1+p^2)\, d\phi}{\{1-\gamma(3p+p^3)\}^{\frac{1}{3}}} = -\frac{u_0}{g}\, {}^{\phi}T_{\gamma}{}^{\phi'} \dots .\ (6),$$

$$x = -\frac{u_0^{\,2}}{g}\, {}^{\phi}\!\int^{\phi'} \frac{(1+p^2)\, d\phi}{\{1-\gamma(3p+p^3)\}} = -\frac{u_0^{\,2}}{g}\, {}^{\phi}X_{\gamma}{}^{\phi'} \dots (7),$$

$$y = -\frac{u_0^{\,2}}{g}\, {}^{\phi}\!\int^{\phi'} \frac{(p+p^3)\, d\phi}{\{1-\gamma(3p+p^3)\}^{\frac{2}{3}}} = -\frac{u_0^{\,2}}{g}\, {}^{\phi}Y_{\gamma}{}^{\phi'} \dots (8).$$

64. Inasmuch as it was impossible to find the values of x, y and t by direct integration, it has been necessary to calculate by quadratures the values of X, Y and T for all practical values of $+\phi$ not greater than 60°, and of $-\phi$ not greater than 60° or 45°, for values of $\gamma = 0{\cdot}00$, $0{\cdot}01$, $0{\cdot}02 \dots 0{\cdot}18$, $0{\cdot}19$, $0{\cdot}2$, $0{\cdot}3$, $0{\cdot}4 \dots 4{\cdot}9$, $5{\cdot}0$. The value of $d\phi$ generally used was the circular measure of 1°, but when $1-\gamma(3p+p^3)$ became small, the successive values of $\dfrac{1}{1-\gamma(3p+p^3)}$ were subject to rapid variation. In such cases intervals of one-fifth of a degree were used, and the results have been given in preliminary Tables (pages 4 to 38). The calculations of the values of X, Y and T were in general carried to one decimal place beyond those given in the printed Tables. By the ordinary rule of proportional parts, or, where great accuracy is required, by interpolation, it will not be difficult to find the values of X, Y and T for values of γ and ϕ intermediate to those given in the Tables.

EXAMPLES OF THE METHODS OF FINDING THE NUMERICAL VALUES OF X, Y, AND T.

65. From the Tables

$${}^{10}X_{0\cdot7}{}^{5} = {}^{10}X_{0\cdot7}{}^{0} - {}^{5}X_{0\cdot7}{}^{0} = {\cdot}20430 - {\cdot}09348 = {\cdot}11082,$$

$${}^{4}Y_{0\cdot7}{}^{10} = {}^{0}Y_{0\cdot7}{}^{10} - {}^{0}Y_{0\cdot7}{}^{4} = {\cdot}013448 - {\cdot}002299 = {\cdot}011149,$$

$${}^{5}T_{3\cdot2}{}^{0} = {\cdot}11027, \quad {}^{0}T_{3\cdot2}{}^{5} = {\cdot}07836.$$

Suppose it was required to find the value of ${}^{3}Y_{3\cdot2}^{7\cdot41}$;

$$\begin{aligned}{}^{3}Y_{3\cdot2}^{7\cdot41} &= {}^{3}Y_{3\cdot2}^{7} + ({}^{3}Y_{3\cdot2}^{8} - {}^{3}Y_{3\cdot2}^{7}) \times 0{\cdot}41,\\ &= {\cdot}004059 + ({\cdot}006548 - {\cdot}005196) \times 0{\cdot}41\\ &= {\cdot}004059 + {\cdot}001352 \times 0{\cdot}41\\ &= {\cdot}004059 + {\cdot}000554\\ &= {\cdot}004613.\end{aligned}$$

In the same way ${}^{3}X_{3\cdot2}^{7\cdot41}$ and ${}^{3}T_{3\cdot2}^{7\cdot41}$ may be found.

Suppose now it was required to find the value of θ in the descending branch which satisfies the equation

$${}_{3}x_{\theta} = \frac{u_0^2}{g}\,{}^{3}X_{2\cdot2}^{\theta}, \text{ when } {}_{3}x_{\theta} \text{ is given} = 500 \text{ feet},$$

$$u_0 = 1000\,f\text{-}s, \quad \text{and } g = 32{\cdot}191.$$

We have

$$\begin{aligned}{}^{3}X_{2\cdot2}^{\theta} &= \frac{g}{u_0^2}\,{}_{3}x_{\theta} = \frac{32{\cdot}191}{(1000)^2} \times 500 = \frac{16{\cdot}096}{1000} = {\cdot}01610\\ &= ({\cdot}06129 - {\cdot}04731) + {\cdot}00212\\ &= {}^{3}X_{2\cdot2}^{4} + {\cdot}00212.\end{aligned}$$

Now the difference of the values of $X_{2\cdot2}$ for 4° and 5° is ${\cdot}07457 - {\cdot}06129 = {\cdot}01328$. Hence by proportional parts $\theta = 4^\circ + \dfrac{{\cdot}00212}{{\cdot}01328} = 4^\circ{\cdot}1596$.

Making use of this value of θ we can now find the corresponding values of ${}_{3}y_{\theta}$ and ${}_{3}t_{\theta}$.

We have supposed hitherto that we had a table calculated for the required value of γ. Suppose, however, we require the numerical value of ${}^{3}Y_{3\cdot237}^{4\cdot41}$.

It has been shewn above that ${}^{3}Y_{3\cdot2}^{7\cdot41} = {\cdot}004613$

and in precisely the same manner we find ${}^{3}Y_{3\cdot3}^{7\cdot41} = {\cdot}004567$

Shewing that an increment of $0{\cdot}1$ in γ gives a decrement in Y $= -{\cdot}000046$

Hence, by proportional parts, an increment of $0{\cdot}037$ gives a decrement in the value of Y $= -{\cdot}000017$

Hence $$ {}^{3}Y_{32\cdot 37}^{\;7\cdot 41} = {}^{3}Y_{32}^{\;7\cdot 41} - \cdot 37 \times \cdot 000046 $$
$$ = \cdot 004613 - \cdot 000017 = \cdot 004596. $$

66. In cases where we can suppose the resistance of the air to vary as the cube of the velocity throughout the range, it is easy to find the path and time of flight of a projectile and its velocity at any point, supposing the initial velocity and initial direction of the shot to be accurately known.

Let V be the initial velocity, α the angle of projection, and $2b$ the coefficient of resistance, then $u = V\cos\alpha$ is known, and equation (2) gives u_0, for

$$ \frac{1}{u_0^3} = \frac{1}{u^3} + \frac{2b}{g}(3p + p^3), $$

or $$ \left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u}\right)^3 + \frac{2b\,(1000)^3}{g}(3\tan\alpha + \tan^3\alpha). $$

Hence we know $\gamma = \dfrac{2bu_0^3}{g}$, and referring to the table for this particular value of γ we obtain, (fig. 8)

$$ OM = \frac{u_0^2}{g}\,{}^{a}X_{\gamma}^{0},\ MA = \frac{u_0^2}{g}\,{}^{a}Y_{\gamma}^{0},\ \text{and time in } OA = \frac{u_0}{g}\,{}^{a}T_{\gamma}^{0}. $$

Now for the *descending* branch, we have, for the point where the motion of the shot is inclined to the horizon at an angle $-\beta$ at P',

$$ \left(\frac{1000}{u'_\beta}\right)^3 = \left(\frac{1000}{u_0}\right)^3 + \frac{2b\,(1000)^3}{g}(3\tan\beta + \tan^3\beta), $$

which gives the value of u'_β, and therefore of $v'_\beta = u'_\beta \sec\beta$.

$$ AN' = \frac{u_0^2}{g}\,{}^{0}X_{\gamma}^{\beta},\ N'P' = \frac{u_0^2}{g}\,{}^{0}Y_{\gamma}^{\beta}, $$

$$ \text{and time in } AP' = \frac{u_0}{g}\,{}^{0}T_{\gamma}^{\beta}. $$

If we wish to find the range on the horizontal plane we must have $AM = N'L$, or

$$ \frac{u_0}{g}\,{}^{a}Y_{\gamma}^{0} = \frac{u_0^2}{g}\,{}^{0}Y_{\gamma}^{\beta},\ \text{or } {}^{a}Y_{\gamma}^{0} = {}^{0}Y_{\gamma}^{\beta}. $$

By the help of the tables β can be found, and this value of β must be used in calculating Mp, and the time in Ap.

67. Suppose it was required to find the height at which the shot would strike a vertical target placed at distance OL, and the time of flight. Here we have

$$ML = LO - OM = \frac{u_0^2}{g}\,{}^0X_\gamma^\beta,$$

or

$${}^0X_\gamma^\beta = (LO - OM)\frac{g}{u_0^2},$$

which gives β by the help of the tables. The value of β so found must be used to find $N'P'$ and the time in AP'. We must proceed in the same way if it be required to find where the shot will be at a given time.

68. It is manifestly easy to calculate the horizontal, and thence the actual velocity, at any given inclination of the trajectory to the horizon. Suppose u_ϕ is the horizontal velocity when the direction of motion is inclined at an angle $+\phi$ to the horizon, that is in the ascending branch OA, and u_ϕ' that when the inclination is $-\phi$ in the descending branch AP', we have

$$\frac{1}{u_\phi^3} = \frac{1}{u_0^3} - \frac{2b}{g}(3\tan\phi + \tan^3\phi),$$

and

$$\frac{1}{u'^3_\phi} = \frac{1}{u_0^3} + \frac{2b}{g}(3\tan\phi + \tan^3\phi).$$

69. *Examples.* The 16-pounder muzzle-loading gun fires an ogival-headed shot 16 lbs. in weight, and 3·54 inches in diameter. If the angle of projection be 2°, and the initial velocity 1358 *f-s*, find the trajectory and time of flight.

Here $u_2 = V\cos\alpha = 1358\cos 2° = 1357{\cdot}2;$

$$w = 16 \text{ lbs.},\ d = 3{\cdot}54 \text{ in.},\ \text{and } \frac{d^2}{w} = {\cdot}7832.$$

The mean coefficient of resistance used is that due to a velocity of 1270 *f-s*, and therefore $K = 108{\cdot}5$ and $\log\frac{K}{g} = {\cdot}5276$,

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u_2}\right)^3 + (1000)^3\frac{2b}{g}P_2 = \left(\frac{1000}{u_2}\right)^3 + \frac{K}{g}\frac{d^2}{w}P_2$$
$$= {\cdot}67666,$$

and therefore $u_0 = 1139\cdot 0\, f\text{-}s.$

$$\gamma = \frac{2bu_0^{\,3}}{g} = (1000)^3 \frac{2b}{g}\left(\frac{u_0}{1000}\right)^3 = \frac{K}{g}\frac{d^2}{w}\left(\frac{u_0}{1000}\right)^3 = 3\cdot 90,$$

$${}^{2}X_{3\cdot 9}^{\;0} = \cdot 04118\,;\quad {}^{2}Y_{3\cdot 9}^{\;0} = \cdot 000761\,;\quad {}^{2}T_{3\cdot 9}^{\;0} = \cdot 03788.$$

$${}_{2}x_0 = \frac{u_0^{\,2}}{g} \times {}^{2}X_{3\cdot 9}^{\;0} = 1659\cdot 7 \text{ feet}\,;\quad {}_{2}y_0 = \frac{u_0^{\,2}}{g} \times {}^{2}Y_{3\cdot 9}^{\;0} = 30\cdot 67 \text{ feet}\,;$$

$${}_{2}t_0 = \frac{u_0}{g} \times {}^{2}T_{3\cdot 9}^{\;0} = 1''\cdot 340.$$

For the descending branch, suppose the mean coefficient of resistance to be that due to a velocity of $1080 f\text{-}s$, and therefore $K = 103\cdot 4$ and $\log\frac{K}{g} = \cdot 5068$. Taking u_0 as the velocity of projection in a horizontal direction, we have

$$\left(\frac{1000}{u'_{2\cdot 4}}\right)^3 = \left(\frac{1000}{u_0}\right)^3 + (1000)^3 \frac{2b}{g} P_{2\cdot 4} = \left(\frac{1000}{u_0}\right)^3 + \frac{K}{g}\frac{d^2}{w} P_{2\cdot 4}$$
$$= \cdot 99318\,;$$

therefore $u'_{2\cdot 4} = 1002\cdot 3\, f\text{-}s.$

$$\gamma = \frac{K}{g}\frac{d^2}{w}\left(\frac{u_0}{1000}\right)^3 = 3\cdot 718.$$

$${}^{0}X_{3\cdot 7}^{\;2\cdot 4} = \cdot 03670\,;\quad {}^{0}Y_{3\cdot 7}^{\;2\cdot 4} = -\cdot 000737\,;\quad {}^{0}T_{3\cdot 7}^{\;2\cdot 4} = \cdot 03920.$$

$${}_{0}x_{2\cdot 4} = 1479\cdot 2 \text{ feet}\,;\quad {}_{0}y_{2\cdot 4} = 29\cdot 70 \text{ feet}\,;\quad {}_{0}t_{2\cdot 4} = 1''\cdot 3871.$$

Let x, y be the coordinates of the centre of gravity of the projectile, and t the time when the shot is moving in the descending branch of its trajectory in a direction inclined to the horizon at an angle of 2°·4 or 2°24′.

$$x = {}_{2}x_0 + {}_{0}x_{2\cdot 4} = 3138\cdot 9 \text{ feet},$$
$$y = {}_{2}y_0 + {}_{0}y_{2\cdot 4} = 0\cdot 97 \text{ feet},$$
$$t = {}_{2}t_0 + {}_{0}t_{2\cdot 4} = 2''\cdot 727,$$

and the velocity

$$= v'_{2\cdot 4} = u'_{2\cdot 4} \sec 2^\circ\cdot 4 = 1002\cdot 3 \sec 2^\circ\cdot 4 = 1003\cdot 2\, f\text{-}s.$$

The range on the horizontal plane

$$= (3138\cdot 9 + 0\cdot 97 \cot 2^\circ 24') \text{ feet}.$$

Similar calculations have been made for a gun of 3·3 inches firing 16 lbs. shot of 3·24 inches in diameter. Here $V = 1307$,

$w = 16$ lbs., $d = 3{\cdot}24$ inches, and $\frac{d^2}{w} = {\cdot}6561$. The following is a statement of the results.

$$u_0 = 1136{\cdot}5 \, f\text{-}s, \quad x = 3101 \text{ feet}, \quad y = -1{\cdot}09 \text{ feet}, \quad t = 2''{\cdot}715,$$

$$u'_{2\cdot4} = 1018{\cdot}6 \, f\text{-}s, \quad \text{and} \quad v'_{2\cdot4} = 1019{\cdot}5 \, f\text{-}s.$$

Hence it appears that if the 3·3 inch gun was fired at an elevation sufficient to give the same range as the 3·6 inch gun when fired at an elevation of 2°, the shot fired from the former gun would have a higher striking velocity, but would then have nearly the same inclination to the horizon. As the elevation was increased, the advantage would be more and more in favour of the 3·3 inch gun, both in striking velocity and flatness of trajectory.

70. A spherical shot weighing 84 lbs. is fired from the 100-pounder smooth-bored gun with an initial velocity of 1564 feet per second. The angle of projection is supposed 5°.

Here $\quad V = 1564 \, f\text{-}s, \; u_5 = 1564 \cos 5° = 1558;$

$$d = 8{\cdot}9 \text{ in.}; \; w = 94 \text{ lbs.}; \; \frac{d^2}{w} = {\cdot}8427; \; \log \frac{d^2}{w} = 9{\cdot}92565.$$

The mean coefficient for the ascending branch is that due to a velocity of $1300 \, f\text{-}s$, therefore $K = 147{\cdot}8$, and $\log \frac{K}{g} = {\cdot}6619$. (Table II),

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u_5}\right)^3 + \frac{K}{g} \frac{d^2}{w} P_5$$

$$= 1{\cdot}28236;$$

therefore
$$u_0 = 920{\cdot}5 \, f\text{-}s,$$

$$\gamma = \frac{K}{g} \frac{d^2}{w} \left(\frac{u_0}{1000}\right)^3 = 3{\cdot}017.$$

By the help of proportional parts, the following values of X, Y, and T are found from the Tables

$$^5X_{3\cdot017}{}^0 = {\cdot}13525; \; ^5Y_{3\cdot017}{}^0 = {\cdot}006\,910; \; ^5T_{3\cdot017}{}^0 = {\cdot}10760;$$

$$_5x_0 = \frac{u_0^2}{g} \times {}^5X_{3\cdot017}{}^0 = 3559{\cdot}7 \text{ feet}; \; _5y_0 = \frac{u_0^2}{g} \times {}^5Y_{3\cdot017}{}^0 = 181{\cdot}9 \text{ feet};$$

$$_5t_0 = \frac{u_0}{g} \times {}^5T_{3\cdot017}{}^0 = 3''{\cdot}077.$$

For the descending branch we suppose the shot projected horizontally with an initial velocity $u_0 = 920{\cdot}5\,f\text{-}s$, and to be acted upon by the resistance of the air varying as the velocity cubed, the mean coefficient used being that due to a velocity of $900\,f\text{-}s$. Here $K = 138{\cdot}2$, and $\log \frac{K}{g} = {\cdot}6329$,

$$\left(\frac{1000}{u'_8}\right)^3 = \left(\frac{1000}{u_0}\right)^3 + \frac{K}{g}\,\frac{d^2}{w}\,P_8$$

$$= 2{\cdot}81811\,;$$

therefore $$u'_8 = 708{\cdot}0\,f\text{-}s$$

and $$\gamma = \frac{K}{g}\,\frac{d^2}{w}\left(\frac{u_0}{1000}\right)^3 = 2.822.$$

From the Tables the values of X, Y, and T are found for $\gamma = 2{\cdot}822$

$${}^0X_{2\cdot822}^{\;8} = {\cdot}10575\,;\quad {}^0Y_{2\cdot822}^{\;8} = -{\cdot}006788\,;\quad {}^0T_{2\cdot822}^{\;8} = {\cdot}12156,$$

whence ${}_0x_8 = 2783{\cdot}2$ ft.; ${}_0y_8 = -\,178{\cdot}6$ ft.; ${}_0t_8 = 3''{\cdot}476$.

But ${}_5x_0 = 3559{\cdot}7$ ft.; ${}_5y_0 = +\,181{\cdot}9$ ft.; ${}_5t_0 = 3''{\cdot}077$;

therefore $x = \overline{6342{\cdot}9}$ ft.; $y = +\;\overline{\;\;3{\cdot}3}$ ft.; $t = \overline{6''{\cdot}553}$;

and $$v'_8 = u'_8 \sec 8^\circ = 715\,f\text{-}s.$$

When the shot is 3·3 feet above the level of the muzzle of the gun in the descending branch, its course is inclined at 8° to the horizon. Hence the range of the shot on the horizontal plane $= (6342{\cdot}9 + 3{\cdot}3 \cot 8^\circ)$ feet.

But suppose that we wished to calculate the *exact* range, time of flight, striking velocity and angle of incidence. In the first place we remark, that as the shot has risen to the height of 181·9 feet, it must fall through an equal height. Let ϕ be the angle of incidence, then in the descending branch ${}_0y_\phi = 181{\cdot}9 \text{ feet} = \frac{u_0^2}{g}\,{}^0Y_{2\cdot822}^{\;\phi}$;

therefore $${}^0Y_{2\cdot822}^{\;\phi} = {\cdot}006910.$$

But $${}^0Y_{2\cdot822}^{\;9} - {}^0Y_{2\cdot822}^{\;8} = {\cdot}008329 - {\cdot}006788 = {\cdot}001541,$$

and $${}^0Y_{2\cdot822}^{\;\phi} - {}^0Y_{2\cdot822}^{\;8} = {\cdot}006910 - {\cdot}006788 - {\cdot}000122.$$

Hence, by proportional parts, we find $\phi = 8^\circ{\cdot}079$ the angle of incidence

$${}^0X_{2\cdot822}^{\;8\cdot079} = {\cdot}10657\,;\ \text{and}\ {}^0T_{2\cdot822}^{\;8\cdot079} = {\cdot}12264,$$

which give ${}_{0}x_{8\cdot079} = 2804{\cdot}9$; ${}_{0}t_{8\cdot079} = 3''{\cdot}507$.

But ${}_{5}x_{0} = 3559{\cdot}7$; ${}_{5}t_{0} = 3''{\cdot}077$.

therefore $\text{X} = 6364{\cdot}6$, $\text{Y} = 0$, $\text{T} = 6''{\cdot}584$.

The striking velocity $v'_{8\cdot079}$ is found from the equations

$$\left(\frac{1000}{u'_{8\cdot079}}\right)^3 = \left(\frac{1000}{u_0}\right)^3 + \frac{K}{g} \times \frac{d^2}{w} \times P_{8\cdot079},$$

and

$$v'_{8\cdot079} = u'_{8\cdot079} \sec 8^\circ{\cdot}079.$$

71. We will now proceed to explain how the tables may be used in calculating the trajectory of an ogival-headed shot when successive arcs are supposed to be described under the action of a retarding force varying as the cube of the velocity. The coefficient of resistance for any arc must be taken approximately, so as to give the mean value of the coefficient for that arc of the trajectory. It will be convenient to change the coefficient of resistance at points where the tangents to the trajectory are inclined to the horizon at angles expressed exactly in some number of degrees, because the values of X, Y, and T are given in all those cases in the Tables. Afterwards, for comparison of the results, the range, &c. will be calculated by the use of only one coefficient for the ascending and one for the descending branch.

An ogival-headed shot 6·34 inches in diameter, weighing 70·6 lbs. is projected at an angle of 5° with an initial velocity of 1335 feet per second; find the path described by the shot, its velocity at various points, its range, and angle of incidence. Here

$$V = 1335 \textit{f-s}, \quad u_5 = 1335 \cos 5^\circ = 1329{\cdot}9 \textit{f-s}, \quad w = 70{\cdot}6 \text{ lbs.},$$

$$d = 6{\cdot}34 \text{ inches}, \quad \frac{d^2}{w} = {\cdot}56935, \quad \log \frac{d^2}{w} = 9{\cdot}75538.$$

The coefficient of resistance for the first arc of the trajectory is that due to a velocity of 1300*f-s*; therefore $K = 107{\cdot}9$ and $\log \frac{K}{g} = {\cdot}5253$,

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u_5}\right)^3 + \frac{K}{g}\frac{d^2}{w} P_5$$

$$= {\cdot}92736, \text{ or } u_0 = 1025{\cdot}5 \textit{f-s}.$$

We must now find the value of u_4,

$$\left(\frac{1000}{u_4}\right)^3 = \left(\frac{1000}{u_0}\right)^3 - \frac{K}{g}\frac{d^2}{w}P_4$$
$$= {\cdot}52635,$$

or $$u_4 = 1238{\cdot}5 \textit{f-s}, \text{ and } v_4 = 1238{\cdot}5 \sec 4^\circ.$$

The value of $$\gamma = \frac{K}{g}\frac{d^2}{w}\left(\frac{u_0}{1000}\right)^3 = 2{\cdot}058,$$

$${}_5x_4 = \frac{{u_0}^2}{g}\,{}^5X_{2\cdot058}{}^4 = 897{\cdot}7 \text{ feet}, \quad {}_5y_4 = \frac{{u_0}^2}{g}\,{}^5Y_{2\cdot058}{}^4 = 70{\cdot}8 \text{ feet},$$

$${}_5t_4 = \frac{u_0}{g}\,{}^5T_{2\cdot058}{}^4 = 0''{\cdot}700.$$

For the arc 4° – 3° we suppose the angle of projection to be 4°, the velocity of projection v_4, and the coefficient of resistance to be that due to a velocity of 1200 *f-s*; therefore $K = 108{\cdot}9$ and $\log\frac{K}{g} = {\cdot}5293$,

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u_4}\right)^3 + \frac{K}{g}\frac{d^2}{w}P_4 = {\cdot}93107,$$

or $$u_0 = 1024{\cdot}1 \textit{f-s}.$$

And $$\left(\frac{1000}{u_3}\right)^3 = \left(\frac{1000}{u_0}\right)^3 - \frac{K}{g}\frac{d^2}{w}P_3 = {\cdot}62797,$$

or $$u_3 = 1167{\cdot}8 \textit{f-s}.$$

The value of $$\gamma = \frac{K}{g}\frac{d^2}{w}\left(\frac{u_0}{1000}\right)^3 = 2{\cdot}069,$$

$${}_4x_3 = \frac{{u_0}^2}{g}\,{}^4X_{2\cdot069}{}^3 = 786{\cdot}2 \text{ feet}, \quad {}_4y_3 = \frac{{u_0}^2}{g}\,{}^4Y_{2\cdot069}{}^3 = 48{\cdot}2 \text{ feet},$$

$${}_4t_3 = \frac{u_0}{g}\,{}^4T_{2\cdot069}{}^3 = 0''{\cdot}654.$$

For the arc 3° – 2° the coefficient of resistance is that which is due to a velocity of 1135 *f-s*; therefore $K = 107{\cdot}7$ and $\log\frac{K}{g} = {\cdot}5244$. The new value of u_0 to be used for this arc is found, as before, $= 1025{\cdot}3$ *f-s* and $u_2 = 1111{\cdot}6$ *f-s*, $\gamma = 2{\cdot}053$, which give

$${}_3x_2 = 704{\cdot}8 \text{ feet}, \quad {}_3y_2 = 30{\cdot}9 \text{ feet}, \quad {}_3t_2 = 0''{\cdot}619.$$

For the arc $2^\circ - 1^\circ$ the coefficient of resistance is that which is due to a velocity of 1090 *f-s*; therefore $K = 105{\cdot}1$ and $\log \frac{K}{g} = {\cdot}5139$, which gives the new value of $u_0 = 1027{\cdot}1$ *f-s*, $u_1 = 1066{\cdot}0$ *f-s*, and $\gamma = 2{\cdot}014$, from which it is found that

$$ {}_2x_1 = 642{\cdot}6 \text{ feet}, \quad {}_2y_1 = 16{\cdot}9 \text{ feet}, \quad {}_2t_1 = 0''{\cdot}590. $$

For the arc $1^\circ - 0^\circ$ the coefficient of resistance is that due to a velocity of 1047 *f-s*; therefore $K = 91{\cdot}4$ and $\log \frac{K}{g} = {\cdot}4532$, which gives $u_0 = 1031{\cdot}9$ *f-s* for the calculated velocity with which the projectile is moving at its highest point, and $\gamma = 1{\cdot}776$, from which it is found that

$$ {}_1x_0 = 596{\cdot}0 \text{ feet}, \quad {}_1y_0 = 5{\cdot}3 \text{ feet}, \quad {}_1t_0 = 0''{\cdot}568. $$

For the descending branch we shall make use of intervals of 2°.

For the arc 0° to -2° the coefficient of resistance is that due to a velocity of 1010 *f-s*; therefore $K = 77{\cdot}5$ and $\log \frac{K}{g} = {\cdot}3817$, and the shot is supposed to be projected horizontally with a velocity $u_0 = 1031{\cdot}9$ *f-s*. It must be remarked that for the descending branch of the curve $P_{-\phi} = -P_\phi$, for

$$ P_{-\phi} = 3 \tan(-\phi) + \tan^3(-\phi) = -(3 \tan\phi + \tan^3\phi) = -P_\phi, $$

$$ \left(\frac{1000}{u'_2}\right)^3 = \left(\frac{1000}{u_0}\right)^3 + \frac{K}{g}\,\frac{d^2}{w}\,P_2 $$

$$ = {\cdot}91020 + {\cdot}14370 = 1{\cdot}05390, $$

or $u'_2 = 982{\cdot}7$ feet and $\gamma = 1{\cdot}506$; from which we find

$$ {}_0x_2 = 1099{\cdot}1 \text{ feet}, \quad {}_0y_2 = -18{\cdot}9 \text{ feet}, \quad {}_0t_2 = 1''{\cdot}092. $$

For the arc -2° to -4° the coefficient of resistance is that due to a velocity of 970 *f-s*; therefore $K = 69{\cdot}6$, $\log \frac{K}{g} = {\cdot}3349$ which gives $u'_0 = 1026{\cdot}4$ *f-s*, $u'_4 = 945{\cdot}4$ *f-s*, and $\gamma = 1{\cdot}331$, from which we find ${}_2x_4 = 1009{\cdot}6$ feet; ${}_2y_4 = -52{\cdot}7$ feet; ${}_2t_4 = 1''.048$.

For the arc -4° to -6° the coefficient of resistance is that due to a velocity of 935 *f-s*; therefore $K = 66{\cdot}2$ and $\log \frac{K}{g} = {\cdot}31345$, which gives the new value of $u'_0 = 1021{\cdot}8$ *f-s*, $u'_6 = 914{\cdot}3$ *f-s*; and $\gamma = 1{\cdot}250$, from which we find

$$ {}_4x_6 = 944{\cdot}5 \text{ feet}, \quad {}_4y_6 = -82{\cdot}4 \text{ feet}, \quad {}_4t_6 = 1''.016. $$

It is now necessary for us to find the height of the shot; since

$$\begin{array}{lrl@{\qquad}lr}
 & {}_5y_4 = & 70{\cdot}8 \text{ feet, and} & {}_0y_2 = - & 18{\cdot}9 \text{ feet,} \\
 & {}_4y_3 = & 48{\cdot}2 & {}_2y_4 = - & 52{\cdot}7 \\
 & {}_3y_2 = & 30{\cdot}9 & {}_4y_6 = - & \underline{82{\cdot}4} \\
 & {}_2y_1 = & 16{\cdot}9 & & -\,154{\cdot}0 \\
 & {}_1y_0 = & \underline{5{\cdot}3} & & +\,\underline{172{\cdot}1} \\
\text{Height of vertex} & = & 172{\cdot}1 & & +\,18{\cdot}1
\end{array}$$

When, therefore, the shot has fallen through an additional vertical height of 18·1 feet it will be in the horizontal plane passing through the point of projection. Suppose $\gamma = 1{\cdot}250$, we find

$$ {}^6X_{1\cdot25}{}^7 = {\cdot}01393; \quad {}^6Y_{1\cdot25}{}^7 = -{\cdot}001587; \quad {}^6T_{1\cdot25}{}^7 = {\cdot}01570. $$

Supposing that ϕ denotes the inclination of the trajectory when it meets the horizontal plane passing through the point of projection, then to determine ϕ we have

$$ {}_6y_\phi = -\,18{\cdot}1 \text{ feet} = \frac{u_0'^2}{g}\, {}^6Y_{1\cdot25}{}^\phi, $$

or

$$ {}^6Y_{1\cdot25}{}^\phi = -\frac{g}{u_0'^2} \times 18{\cdot}1 = -{\cdot}000558. $$

Hence it is found by proportional parts that $\phi = 6^\circ{\cdot}352$.

$$ {}_6x_{6\cdot352} = \frac{u_0'^2}{g}\, {}^6X_{1\cdot25}{}^{6,352} = 159{\cdot}1 \text{ feet}, \quad {}_6t_{6\cdot352} = \frac{u_0'}{g}\, {}^6T_{1\cdot25}{}^{6,352} = 0''{\cdot}175. $$

$$\begin{array}{rl@{\qquad}lr}
{}_5x_4 = & 897{\cdot}7 \text{ feet} & {}_0x_2 & = 1099{\cdot}1 \text{ feet} \\
{}_4x_3 = & 786{\cdot}2 & {}_2x_4 & = 1009{\cdot}6 \\
{}_3x_2 = & 704{\cdot}8 & {}_4x_6 & = 944{\cdot}5 \\
{}_2x_1 = & 642{\cdot}6 & {}_6x_{6\cdot352} & \underline{159{\cdot}1} \\
{}_1x_0 = & \underline{596{\cdot}0} & & +\,3212{\cdot}3 \\
 & 3627{\cdot}3 & & +\,\underline{3627{\cdot}3} \\
 & & \text{therefore } \mathrm{X} & = 6839{\cdot}6 \text{ feet}
\end{array}$$

$$\begin{array}{rl@{\qquad}lr}
{}_5t_4 = & 0''{\cdot}700 & {}_0t_2 & = 1''{\cdot}092 \\
{}_4t_3 = & 0{\cdot}654 & {}_2t_4 & = 1{\cdot}048 \\
{}_3t_2 = & 0{\cdot}619 & {}_4t_6 & = 1{\cdot}016 \\
{}_2t_1 = & 0{\cdot}590 & {}_6t_{6\cdot352} & = \underline{0{\cdot}175} \\
{}_1t_0 = & \underline{0{\cdot}568} & & 3{\cdot}331 \\
 & 3{\cdot}131 & & \underline{3{\cdot}131} \\
\mathrm{Y} = 0 & & \text{therefore } \mathrm{T} = & 6{\cdot}462 \text{ seconds}
\end{array}$$

72. We will now proceed to calculate the last example by two steps, the division being at the vertex of the trajectory. For the ascending branch take the coefficient due to a velocity of 1180 *f-s*, therefore $K=108\cdot9$ and $\log\frac{K}{g}=\cdot5290$, therefore

$$\left(\frac{1000}{u_0}\right)^2=\left(\frac{1000}{u_5}\right)^2+\frac{K}{g}\frac{d^2}{w}P_5,$$

which gives $u_0=1023\cdot9$ *f-s*, $\gamma=\frac{K}{g}\frac{d^2}{w}\left(\frac{u_0}{1000}\right)^2=2\cdot066$,

and ${}_5x_0=3617\cdot5$; ${}_5y_0=171\cdot9$; and ${}_5t_0=3''\cdot127$.

For the descending branch we shall use the coefficients due to a velocity of 950 *f-s*; therefore $K=67\cdot4$ and $\log\frac{K}{g}=\cdot3210$. This gives $\gamma=1\cdot280$, and the angle of incidence on the horizontal plane passing through the muzzle of the gun $=6^\circ\cdot349$.

${}_0x_{6\cdot349}=3203\cdot5$ ft.; ${}_0y_{6\cdot349}=-171\cdot9$ ft.; and ${}_0t_{6\cdot349}=3''\cdot328$;
but ${}_5x_0=3617\cdot5$ ft.; ${}_5y_0=+171\cdot9$ ft.; and ${}_5t_0=3''\cdot127$;
$\therefore$ X $=6821\cdot0$ ft.; Y $=0$ ft.; and T $=6''\cdot455$.

The former values were

X $=6839\cdot6$; Y $=0$; and T $=6''\cdot462$.

The coefficients given in Table I. for ogival-headed elongated shot, and other kindred forms, and those in Table II. for spherical shot, have been found for the highest velocities likely to be obtained in practice. But the coefficients for velocities below about 1000 *f-s* require to be determined by a special set of experiments. These are, however, of far less importance than those for higher velocities.

Also, if any different form of projectile should be required for use, then it would only be necessary to find a new table of values of K for that particular form of head. All the remaining tables would then be applicable.

If the tables should be required for some place on the earth's surface, where the force of gravity g' was sensibly different from g, the force of gravity at Greenwich, then all the values of $\log\frac{K}{g}$ would be required to be increased by $\log\frac{g}{g'}$.

73. The preceding investigations of the path described by a projectile moving through the air are based upon the supposition that the resistance of the air acts through the

centre of gravity of the shot, and in the direction of a tangent to its path. These would apply strictly to the case of a spherical shot which did not rotate and whose centre of gravity coincided with its centre of figure, and its motion would lie entirely in the vertical plane of projection. But we should only obtain by this means an approximation to the path described by an elongated shot fired from a rifled gun. Practically, a shot of this kind is found to deviate to the *right*, when the rifling communicates a *right*-handed rotation as seen from the gun. If there were no resistance of the air, then the centre of gravity of the shot would describe a parabola, and the axis of the shot would continue parallel to its original direction, as is represented in fig. 8^a, just as the earth moves in her orbit and maintains the parallelism of her axis of rotation. The resistance of the air alters all this. It causes elongated shot to move approximately point foremost. Thus when an elongated ogival-headed shot escapes from a rifled gun, it is moving in the direction of its axis, or very nearly so. The action of gravity very soon causes the axis of the shot GB, (fig. 9^a), to make a small angle with CD, the direction in which G, the centre of gravity of the shot, is moving. The resultant resistance of the air then tends to turn the shot about an axis through G, perpendicular to the plane BGD, so as to *increase* the angle BGD. If the shot had no rotation, the shot would fly end over end. But if the shot seen from C had a *right*-handed rotation about its axis, this motion would be combined with that which the resistance of the air tended to impart to the shot, and, in consequence, the point A as seen from C would be slightly deflected to the right. Suppose this continued, then the consequence would be that the axis GA would describe a cone about CD, rotating in the same direction as the shot rotates about its own axis. We have been considering the motion about the centre of gravity G, supposed fixed. If we now consider the motion of translation of the shot, we shall easily see that the resistance of the air, acting normally to every part of the surface of the shot, will have a resolved part which will be effective in a slight degree in pushing the shot away from CD, the direction of its motion. Thus the shot will have a sinuous motion. But as the *first* deflection of an ogival-headed shot spinning with right-handed rotation is to the right, and afterwards, as its point is directed more to the right than to the left, the shot will have a deviation on the whole greater to the right than to the left.

74. If the form of the head of the shot, or the position of the centre of gravity of the shot, was such that the resistance of the air tended to *diminish* the angle BGD, then, the shot having a right-handed rotation as seen from C, the axis GA would have a left-handed rotation about the tangent CD, and the resulting deviation of the shot from its vertical plane of projection would be to the left. This is the case with a flat-headed shot.

Professor Magnus[*] has shewn how to illustrate the motion of rifled shot by means of the gyroscope, and General Mayevski[†] has published a mathematical investigation on the subject. For practical illustrations see a paper on the Derivation of Elongated Projectiles, by Major Owen, R.A.[‡]

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[*] *Ueber die Abweichung der Geschosse*, 1860; and first edition translated in Taylor's *Scientific Memoirs*, 1853.

[†] *De l'influence du Mouvement de Rotation sur la Trajectoire des Projectiles oblongs, dans l'Air. Revue de Technologie Militaire*, t. v., p. 13, 1866.

[‡] *Proceedings of the R.A. Institution*, Vol. IV., p. 185; and *Treatise on Modern Artillery*, p. 224.

CHAPTER V.

DESCRIPTION AND USE OF THE GENERAL TABLES.

75. It will be found sufficient for many practical purposes to neglect the effect of gravity and treat the motion of a shot as if its path were a straight line. This will suffice for experimental purposes when it is desired to find the loss of velocity, or the time of flight for a limited space, the initial velocity being high. The less the shot is affected by the resistance of the air the more accurate will be the results. Therefore this method will apply better to pointed elongated shot than to spherical shot, and better to solid shot than to shell of the same external form.

76. The equation of motion for the cubic law of resistance is

$$\frac{d^2s}{dt^2} = \frac{dv}{dt} = -2bv^3,$$

and therefore $$\frac{1}{2}\frac{1}{v^2} = C + 2bt.$$

Suppose that $v = V$ when $t = 0$, $s = 0$, then $C = \frac{1}{2}V^2$, and

$$\frac{1}{v^2} - \frac{1}{V^2} = 4bt = 2tK\frac{d^2}{w}\frac{1}{(1000)^3}, \text{ if } K = 2b\frac{w}{d^2}(1000)^3,$$

or $$\frac{d^2}{w}t = \frac{500}{K}\left\{\left(\frac{1000}{v}\right)^2 - \left(\frac{1000}{V}\right)^2\right\} \text{..............} (1),$$

which connects t and v.

Again, $$v\frac{dv}{ds} = -2bv^3,$$

and integrating, $$\frac{1}{v} = C' + 2bs,$$

or
$$\frac{1}{v} - \frac{1}{V} = 2bs = sK\frac{d^2}{w}\,\frac{1}{(1000)^3},$$

or
$$\frac{d^2}{w}\,s = \frac{(1000)^2}{K}\left\{\left(\frac{1000}{v}\right) - \left(\frac{1000}{V}\right)\right\} \dots\dots\dots\dots (2),$$

which connects s and v.

If in the equation $\frac{1}{v} - \frac{1}{V} = 2bs$, we substitute $\frac{dt}{ds}$ for $\frac{1}{v}$, we have

$$\frac{dt}{ds} = \frac{1}{V} + 2bs,$$

and integrating, we have

$$t = \frac{s}{V} + bs^2 \dots\dots\dots\dots\dots\dots (3),$$

which connects t and s.

If we divide
$$\frac{1}{v^2} - \frac{1}{V^2} = 4bt$$

by
$$\frac{1}{v} - \frac{1}{V} = 2bs,$$

we obtain
$$\frac{1}{v} + \frac{1}{V} = \frac{2t}{s} \dots\dots\dots\dots\dots\dots (4),$$

which connects v, t, and s independently of $2b$ the coefficient of resistance.

77. In determining the velocity of a shot it is usual to measure the time in which a given *short* range is described, and then, dividing the space in feet by the time in seconds, the result is adopted as the approximate velocity at the middle point. If the cubic law of the resistance of the air be supposed sufficiently near the truth, this may easily be shewn to be strictly correct for any range, so long as the path of the shot may be considered to be a straight line.

We have seen that when V is the initial velocity and v the velocity at the distance s, then

$$\frac{1}{v} = \frac{1}{V} + 2bs,$$

or if v' be the velocity at the distance $\frac{s}{2}$, then

$$\frac{1}{v'} = \frac{1}{V} + bs.$$

Also $\dfrac{\text{space in feet}}{\text{time in seconds}} = \dfrac{s}{t} = \dfrac{s}{\dfrac{s}{V} + bs^2}$, by equation (3),

$$= \frac{1}{\dfrac{1}{V} + bs} = v',$$

the true velocity at the middle point of the range s.

78. Inasmuch as the resistance of the air does not vary strictly as the cube of velocity, when formulæ (1), (2), and (3) are used for considerable differences of V and v, it is necessary to use several numerical values of K. But as this would be a troublesome operation to perform in each case, general Tables of the values of $\dfrac{500}{K}\left\{\left(\dfrac{1000}{v}\right)^2 - \left(\dfrac{1000}{V}\right)^2\right\}$ for spherical and ogival-headed shot, Tables (IX.) and (XI.), and also of the values of $\dfrac{(1000)^2}{K}\left\{\dfrac{1000}{v} - \dfrac{1000}{V}\right\}$ for spherical and elongated shot, Tables (VIII.) and (X.) have been calculated. It is manifest that these quantites depend upon v and V, which are quite independent of the nature of the shot, while K is a coefficient dependent on the *form* of the projectile but not at all upon its *weight* and *diameter*.

79. Suppose the initial velocity to be V, and that the velocity falls from V to v_1, in space s_1, and in time t_1; from v_1 to v_2 in space s_2, and in time t_2; from v_2 to v_3 in space s_3, and in time t_3; ... and from v_{n-1} to v_n, in space s_n, and in time t_n. Let $K_1, K_2, K_3, \ldots K_n$ be the particular values of K due to the mean of velocities V and v_1, v_1 and v_2, v_2 and $v_3 \ldots v_{n-1}$ and v_n. Then we have from equation (1)

$$\frac{d^2}{w}t_1 = \frac{500}{K_1}\left\{\left(\frac{1000}{v_1}\right)^2 - \left(\frac{1000}{V}\right)^2\right\},$$

$$\frac{d^2}{w}t_2 = \frac{500}{K_2}\left\{\left(\frac{1000}{v_2}\right)^2 - \left(\frac{1000}{v_1}\right)^2\right\},$$

$$\frac{d^2}{w}t_3 = \frac{500}{K_3}\left\{\left(\frac{1000}{v_3}\right)^2 - \left(\frac{1000}{v_2}\right)^2\right\},$$

$$\&c. = \qquad \&c.,$$

$$\frac{d^2}{w}t_n = \frac{500}{K_n}\left\{\left(\frac{1000}{v_n}\right)^2 - \left(\frac{1000}{v_{n-1}}\right)^2\right\}.$$

And summing each side of the equation we have

$$\frac{d^2}{w}\Sigma t_n = 500\Sigma\frac{1}{K_n}\left\{\left(\frac{1000}{v_n}\right)^2 - \left(\frac{1000}{v_{n-1}}\right)^2\right\} \text{ .... (I).}$$

Proceeding in the same way with equation (2) we have

$$\frac{d^2}{w}s_1 = \frac{(1000)^2}{K_1}\left\{\frac{1000}{v_1} - \frac{1000}{V}\right\},$$

$$\frac{d^2}{w}s_2 = \frac{(1000)^2}{K_2}\left\{\frac{1000}{v_2} - \frac{1000}{v_1}\right\},$$

$$\&c. = \qquad \&c.;$$

therefore
$$\frac{d^2}{w}\Sigma s_n = (1000)^2\Sigma\frac{1}{K_n}\left\{\frac{1000}{v_n} - \frac{1000}{v_{n-1}}\right\} \text{ ...... (II).}$$

In calculating the numerical values of the right-hand members of the above equations, V was taken (for elongated shot) $=1700$ *f-s*; $v_1=1690$; $v_2=1680$; $v_3=1670$, &c., and K_1 the coefficient corresponding to the velocity 1695 *f-s*, K_2 to 1685, K_3 to 1675, &c. Tables of the values of $\frac{d^2}{w}t$ and $\frac{d^2}{w}s$ were thus formed corresponding to a loss of every ten feet in the velocity. By interpolation the values of $\frac{d^2}{w}t$ and of $\frac{d^2}{w}s$ which have been given in the Tables, were found for every foot lost in velocity.

It unfortunately happens that equation (3) does not admit of the formation of a general Table to connect directly *space* and *time*. But the use of the two general Tables connecting *velocity* and *space*, and *velocity* and *time*, enable us to calculate the *time* occupied in describing a *given space*, or the space described in a *given time*, the initial velocity being known.

EXAMPLES OF THE USE OF THE GENERAL TABLES.

80. (1) Suppose it was asked in what range an 11·52 inch ogival-headed shot weighing 600 lbs. would have its velocity reduced from 1400 to 1300 *f-s*. Here $d^2 \div w = {\cdot}2212$. Let s denote the required space, then

$$\frac{d^2}{w}s = {\cdot}2212s = 1865 - 1348 = 517,$$

the difference of the ranges opposite 1400 and 1300 *f-s* in Table VIII. Hence

$$s = 517 \div {\cdot}2212 = 2337 \text{ feet.}$$

(2) Suppose now it was asked in what time (t) the velocity of the same shot would be reduced from 1400 to 1300 *f-s*. Here $\frac{d^2}{w}\,t = {\cdot}2212t = 1''{\cdot}258 - 0''{\cdot}875 = 0''{\cdot}383$, the difference of the times opposite 1400 and 1300 *f-s* in Table IX. Hence

$$t = 0''{\cdot}383 \div {\cdot}2212 = 1''{\cdot}732.$$

(3) If, on the other hand, the initial velocity being given 1350 *f-s*, it was required to find what would be the loss of velocity in 500 yards = 1500 feet, we should have given $\frac{d^2}{w}\,s = {\cdot}2212 \times 1500 = 331{\cdot}8$, the *reduced range*. Now opposite the initial velocity 1350 *f-s* in Table VIII. we find 1599, to which must be added the reduced range 331·8, making 1930·8; and corresponding to this we find the velocity 1288·2 *f-s*, by the same Table. Hence the velocity of an 11·52 inch 600 lb. elongated shot would fall from 1350 to 1288·2 *f-s* in 500 yards.

(4) In like manner, if it was required to find how much the velocity of the same shot would be reduced in half a second, its initial velocity being 1334 *f-s*, we must find the *reduced time* $= \frac{d^2}{w}\,t = {\cdot}2212 \times 0''{\cdot}5 = 0''{\cdot}1106$. Adding this to $1''{\cdot}120$, the number opposite the velocity 1334 *f-s* in Table IX. we obtain $1''{\cdot}2306$. And opposite $1''{\cdot}2306$ we obtain by proportional parts 1306·6 *f-s*, which is the velocity the shot will retain at the end of half a second.

(5) Suppose a Rodman shot weighing 452 lbs. to be fired with an initial velocity of 1400 *f-s* at a target 500 yards off, to find the striking velocity. Here $d = 14{\cdot}88$ inches $\frac{d^2}{w} = {\cdot}4898$. Then $\frac{d^2}{w}\,s = {\cdot}4898 \times 1500 = 734{\cdot}7$, the reduced range. Opposite the velocity 1400 in Table X. we find 1501, and adding 734·7 to this, we have 2235·7, opposite which, in the same Table, we find the velocity 1215·8 *f-s*, which is the required striking velocity.

81. The general Table may be used to test the accuracy of some of the early experiments made with the chronograph represented in the frontispiece. From experiment *alone* the

average velocity of eleven shot at every ten feet from the gun was calculated and published in 1866, for distances between 130 and 1000 feet.* Here $d=3$ inches, $w=11\cdot7$ lbs., and $\frac{d^2}{w}=\cdot7692$. Suppose the velocity to be 1141·3 *f-s* at distance 200 feet, to find the velocities at 600 and 1000 feet.

Here $V=1141\cdot3$, opposite which in Table VIII. we find 2850, to which must be added $s\frac{d^2}{w}=400\times\cdot7692=307\cdot7$ giving 3157·7. Opposite this number we find 1100·0 *f-s*. Also $800\times\cdot7692+2850=3465\cdot4$, opposite which number we find 1063·0 *f-s*.

Distances.	200 feet.	600 feet.	1000 feet.
Velocities deduced from actual experiment in 1866...........	1141·3 *f-s*	1098·7 *f-s*	1061·7 *f-s*
Velocities calculated from the general Table VIII.	1141·3	1100·0	1063·0
Differences	0	+ 1·3	+ 1·3

Also Tables of velocities of variously formed heads of shot at distances varying from 0 to 4500 feet, were appended to the second Report dated 1866.† The initial velocity was supposed to be 1500 *f-s* in all cases. Taking the Table for an ogival head (1 diam.) where $w=39\cdot56$ lbs. and an ogival head (2 diam.) where $w=38\cdot50$ lbs. and $d=4\cdot7$ inches, we find

Distances.	0	2000 feet.	4000 feet.
Ogival (1 diam.) $\left(\frac{d^2}{w}=\cdot5584\right)$	1500 *f-s*	1267·9 *f-s*	1098·1 *f-s*
Calculated by the general Table VIII.	1500	1277·2	1106·2
Differences	0	+ 9·3	+ 8·1
Ogival (2 diam.) $\left(\frac{d^2}{w}=\cdot5738\right)$	1500 *f-s*	1271·7 *f-s*	1103·7 *f-s*
Calculated by the general Table VIII.................	1500	1271·7	1098·2
Differences	0	0	− 5·5

The general Table VIII. was deduced from experiments made with ogival-headed shot struck with a radius of one diameter and a-half. The consistency of these results is very striking.

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[*] *Description of a Chronograph*, p. 25.

[†] *Reports, &c.* p. 15.

82. For high initial velocities (V), and low angles of projection (α), the general Tables may be used to find approximately the time of flight and trajectory of the shot. Thus, suppose V the initial velocity, and v the velocity when the shot would have described the space Op (fig. 8) in time t if gravity had not acted. Then, by the general Tables VIII. to XI., it is possible to find Op and t. If x, y be the coordinates of p at time t, then

$$\left.\begin{aligned} x &= Op \cos\alpha \\ y &= Op \sin\alpha - \tfrac{1}{2}gt^2 \end{aligned}\right\}$$

become known because Op and t are known approximately.

Table XII. will be useful to find the values of $\frac{1}{2}gt^2$.

On the principle of these General Tables, special Tables of the velocity, time of flight and energy of each kind of rifled service shot have been calculated for intervals of one hundred feet, and recently published under the title:—

Tables of Remaining Velocity, Time of Flight, and Energy of various projectiles calculated from the results of experiments made with the Bashforth Chronograph, 1865–1870. London: E. and F. N. Spon, 1871.

CHAPTER VI.

ON THE LAW OF PENETRATION OF PROJECTILES.

83. A KNOWLEDGE of the destructive effects of projectiles is of so much importance that it does not seem desirable to omit all consideration of the subject, although I have no new results to communicate.

A Commission, appointed by the French Minister of War, carried on experiments at Metz in 1834 and 1835 with a view to determine the law of penetration of spherical shot into various kinds of wood, masonry, and earth. The conclusions arrived at were, first, that the resistance of the same substance to spherical shot of *different diameters*, varied as the square of the diameter of the shot; and, secondly, that the resistance of *different substances* to the same shot varied as $\alpha + \beta \times (\text{velocity})^2$, where α and β were constant for each substance. If, therefore, d be the diameter of the shot in inches, w its weight in pounds, and v its velocity in feet per second, then the resistance to the shot will be expressed by $\frac{1}{4}\pi d^2 (\alpha + \beta v^2) = d^2 (\lambda + \mu v^2)$, and the retarding force by $\frac{g}{w} d^2 (\lambda + \mu v^2)$.

The following are the values of λ, μ, and $\frac{\lambda}{\mu}$ calculated from the values α and β, as given by Didion,* and adapted to English measures.

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* Didion, *Traité*, pp. 301, 302, and 304.

Substances.	λ	μ	$u=\sqrt{\left(\frac{\lambda}{\mu}\right)}$
Oak, Beech, and Ash	2329·4	·004328	734
Elm	1787·5	·003322	734
Fir and Birch	1296·0	·002408	734
Poplar	1217·7	·002263	734
Sand, mixed with Gravel	486·0	·009031	232
Earth, mixed with Sand and Gravel	670·3	·012456	232
Clayey soil	1167·5	·003799	554
Earth from an old Parapet	782.0	·004360	424
Damp Clay	297.2	·002209	367
Moistened Clay	102·4	·000762	367
Masonry of good quality	6166·9	·008595	847
Masonry of medium quality	4915·7	·006851	847
Brickwork	3530·4	·004920	847

84. Suppose that V is the striking velocity of a spherical shot, and that when it has penetrated a distance s, in time t, its velocity is v. Let S and T denote the values of s and t respectively when the shot comes to rest, that is, when $v=0$.

We have $$v\frac{dv}{ds}=-\frac{gd^2}{w}(\lambda+\mu v^2).$$

Integrating, $$C-\frac{2d^2g\mu s}{w}=\log_\epsilon(\lambda+\mu v^2),$$

and since $s=0$, when $v=V$, $C=\log_\epsilon(\lambda+\mu V^2)$,

or $$s=\frac{w}{2d^2g\mu}\log_\epsilon\left(\frac{\lambda+\mu V^2}{\lambda+\mu v^2}\right)$$

$$=\frac{1\cdot1513w}{d^2g\mu}\log_{10}\left(\frac{\lambda+\mu V^2}{\lambda+\mu v^2}\right)\ldots\ldots\ldots\ldots(1),$$

And total penetration $$=\text{S}=\frac{1\cdot1513w}{d^2g\mu}\log_{10}\left(1+\frac{\mu}{\lambda}V^2\right)$$

$$=\frac{1\cdot1513w}{d^2g\mu}\log_{10}\left\{1+\left(\frac{V}{u}\right)^2\right\}.$$

85. Again, to find the time t in which the velocity is reduced from V to v, we have

$$\frac{dv}{dt} = -\frac{gd^2}{w}(\lambda + \mu v^2).$$

Integrating, $C' - g\dfrac{d^2\mu}{w}t = \sqrt{\left(\dfrac{\mu}{\lambda}\right)} \tan^{-1} v \sqrt{\left(\dfrac{\mu}{\lambda}\right)}$.

But when $v = V$, $t = 0$, therefore

$$C' = \sqrt{\left(\frac{\mu}{\lambda}\right)} \tan^{-1} V \sqrt{\left(\frac{\mu}{\lambda}\right)}.$$

Hence

$$t = \frac{w}{gd^2}\frac{1}{\sqrt{(\lambda\mu)}}\left\{\tan^{-1} V \sqrt{\left(\frac{\mu}{\lambda}\right)} - \tan^{-1} v \sqrt{\left(\frac{\mu}{\lambda}\right)}\right\} \ldots\ldots (2).$$

And the total time of penetration is found by making $v = 0$, when we obtain

$$\mathrm{T} = \frac{w}{gd^2}\frac{1}{\sqrt{(\lambda\mu)}}\tan^{-1} V \sqrt{\left(\frac{\mu}{\lambda}\right)} = \frac{w}{gd^2}\frac{1}{\sqrt{(\lambda\mu)}}\tan^{-1}\frac{V}{u}.$$

86. Between equations (1) and (2) we might elimate v, and thus express s in terms of t, or t in terms of s, and known quantities; or, writing $\dfrac{ds}{dt}$ for v in equations (1) and (2) we might integrate again. But it will be found more convenient to give certain values to v in equations (1) and (2), and thence calculate the corresponding values of s and t.

87. When a spherical shot was fired into a substance which retained its form, the diameter of the cross section of the opening was found to decrease gradually, till it became at last equal to that of the shot. And the section made by a plane along the axis of the opening had its convexity turned towards the axis. From the Metz experiments, it was also concluded that when a given shot was fired into a given substance, but with different velocities, that the volume of the opening made varied as the *vis viva* of the shot on striking. Let y be the radius of a section of the opening at depth s when the velocity of the shot is v. Then we have

$$\frac{1}{2}\frac{w}{g}(V^2 - v^2) = k\,{}^{0}\!\int^{s} y^2 ds.$$

Differentiating, $-\frac{w}{g}\,v\,\frac{dv}{ds} = ky^2 = d^2\,(\lambda + \mu v^2)$, by Art. (84),

or $$y^2 = \frac{d^2}{k}\,(\lambda + \mu v^2).$$

And when $$v = 0,\ 2y = d,$$

therefore $$\frac{d^2}{4} = \frac{d^2}{k}\,\lambda, \text{ or } k = 4\lambda.$$

Hence $$y^2 = \tfrac{1}{4}d^2\left(1 + \frac{\mu}{\lambda}\,v^2\right) \ldots\ldots\ldots\ldots\ldots\ldots (3).$$

And the radius of the mouth of the opening

$$= \frac{d}{2}\sqrt{\left(1 + \frac{\mu}{\lambda}\,V^2\right)}.$$

By equation (1), we have

$$s = \frac{w}{2d^2 g\mu}\left\{\log_\epsilon\left(1 + \frac{\mu}{\lambda}\,V^2\right) - \log_\epsilon\left(1 + \frac{\mu}{\lambda}\,v^2\right)\right\}$$
$$= \frac{w}{2d^2 g\mu}\left\{\log_\epsilon\left(1 + \frac{\mu}{\lambda}\,V^2\right) - 2\log_\epsilon\frac{2y}{d}\right\},$$

which gives the equation to the section of the opening made by a plane along its axis.

88. Additional experiments were made at Gâvre,* in 1835, 1843, and 1844, to determine the penetrations of spherical shot. The penetrations obtained at Metz were a little deeper than those obtained at Gâvre. But it is plain that no great precision can be arrived at in such experiments. Substances of the same name may have very different degrees of consolidation. As the ballistic pendulum was in use when these experiments were made, it was not possible to measure the velocity of the shot which actually made the openings in the substances fired at.

89. M. Didion assumes† that the formulæ used in calculating the penetration of a spherical shot into any substance, may be employed to calculate the penetration of an elongated shot into the same substance, provided the coefficients λ and

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* Helié, *Traité*, p. 192, 196.

† Didion, *Traité*, p. 296.

μ are replaced by $\frac{2}{3}\lambda$ and $\frac{2}{3}\mu$. The resistance to an elongated shot, d inches in diameter, will then be expressed by $\frac{2}{3}d^2(\lambda+\mu v^2)$. But it is manifest that much would depend upon the form of the head of the elongated shot. The results of a few experiments with 7-inch, 70-pr., 40-pr., 20-pr., and 12-pr. elongated shot, when fired into compact loam, are given in the *Handbook for Field Service*, 1867, p. 110.

90. Although a vast number of random shots have been fired against iron plates, no systematic series of experiments have been made to determine, in a satisfactory manner, the law of perforation of iron plates by elongated shot. Before anything of the kind could be attempted with success, it would be necessary (1) to perfect the rolling of thick plates of iron so that they should not be caused to separate into thin layers when struck by the shot, and (2) to improve the manufacture of the elongated shot so that they should not break up or sensibly change their form in penetrating iron plates. In the next place it would be necessary (3) to determine the best form of head for penetration, by firing, with equal velocities, a number of elongated shot of equal weights and diameters, provided with variously formed heads, against given plates. After these preliminaries were settled there would still remain the following four quantities subject to variation: (4) the weight of the shot; (5) the diameter of the shot; (6) the velocity of the shot; and (7) the thickness of the plate of iron. In experimenting it would be necessary to keep two of these four quantities constant, to give to a third variations *following a law*, and then by experiment to determine the corresponding values of the remaining quantity, which must of necessity *follow some law*. Thus, in the first place, the *weight* and *diameter* of the shot might be constant, the *striking velocity* of the shot might be made in succession 900, 1000, 1100, 1200, and 1300 *f-s*, and the corresponding *thicknesses* of plate, which the shot would just perforate, might be found by experiment. In cases where the projectile passed completely through a plate, its remaining velocity would be best measured by taking the depth of its penetration into sand, or some more suitable substance.

If such a series of experiments were to be undertaken, I should particularly advocate the use of guns with bores of ½ to 3 inches, in connection with suitable thicknesses of iron plates. I believe the law of penetration would, in this way, be more accurately and far more cheaply determined than by the use of the large guns now in the service. In confirmation of this opinion, I refer to the comparatively good results obtained by Robins and Hutton in experiments made with small calibres, by the aid of such a rude instrument as the ballistic pendulum.

The late Ordnance Select Committee were accustomed to calculate the perforating power of a shot on the supposition that the *vis viva* of the shot must vary as the diameter of the shot, and as the square of the thickness of the plate.* But on the Continent it is thought necessary to make the *vis viva* of the shot vary as the *square* of its diameter. The approximate law, however, must remain in doubt till a systematic course of experiments has been made with *small calibres*, and with shot which will perforate without *breaking up*, or sensibly changing their form.

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* *British Association Reports for* 1866, p. 411.

APPENDIX.

I.

ADAPTATION OF THE CHRONOGRAPH SHEWN IN THE FRONTISPIECE TO MEASURE A SUCCESSION OF EXTREMELY SHORT INTERVALS OF TIME.

When I brought forward my original scheme for a Chronometric Instrument adapted for Ballistic Experiments, I lithographed a rough sketch to explain my plans to the late Ordnance Select Committee. The following explanatory description, which was appended, will be sufficiently intelligible without the diagrams:—

"In all experiments relating to the velocities of projectiles, to the "resistances of the air to their motion, or to the effects of projectiles "upon iron plates, it is necessary,

"(1) that the time should be registered by a clock of known rate of "going, and

"(2) That the time of flight over *several successive equal* spaces "should be measured by the *same* instrument under the *same* con-"ditions.

"The adjoining plan has been compiled with a view to secure these "two results. The revolving cylinder is in use at Greenwich; the "spark from a Ruhmkorff's Coil is used by Martin de Brettes; and "Prof. A. Vignotti, of Metz, teaches how to prepare the paper so that "the hole burnt by the spark may have a black rim and thus become "easily visible.

"Fig. 1. *abcd* is a cylinder having a metallic surface always kept in "connection with the wires *by*, *cz*, by contact springs at *b* and *c*.

"*e*, *f* are points from which the clock and screen sparks respectively "proceed, whenever the currents *vuy*, *wxz*, are interrupted for an instant.

"*g* is a fly wheel mounted on an axis *h* which drives the cylinder *abcd*.

"*i*, *j* are toothed wheels which turn the screw *o*, and thus give a uni-"form motion to the carriage *k* along the bar *lm*. Thus the holes made "by the sparks from the points *e*, *f*, will be arranged in two spirals.

"As each experiment will be completed in a few seconds, it seems "undesirable to complicate the instrument with any more machinery "for driving the cylinder. If the fly wheel be set in motion (as a "gyroscope) the rotation of the cylinder will diminish very slowly, "and the diminishing distances of the seconds marks will point out the "nature and amount of the necessary corrections. The cylinder *abcd* "is covered with prepared paper.

"Fig. 2. *w*, *v*, are two galvanic batteries, and *y*, *z*, two Ruhmkorff's "Coils. The current from *v* is broken for every beat of the Clock "Pendulum, and at the same instant a spark from *e* makes a hole in the "paper covering of the cylinder. When a ball from a cannon passes "through the screens s_1, s_2, $s_3 \ldots s_{n-1}$, s_n, it will interrupt the current in "wxz, and thus give a spark at f.

"Fig. 3 shews an arrangement for making and breaking the "current. GH is a strong but light chain fixed at G and attached to "the lever ED at H. The lever is kept in contact with CB at C by a "strong spring K. The cross wires of the screen are fixed at one end "to the frame, whilst the other end, after being bent downward over a "pulley, is fixed to the chain GH. When a ball passes through the "screen it bends the wires, pulls the chain, raises the lever ED about "$\frac{1}{20}$ of an inch from C, and causes it to rest against C'. The wire "breaks and the spring K brings D in contact with C again and so "renews the current.

"*April* 19, 1864. (Signed) F. BASHFORTH."

Thus it is plain (1) that the rotating cylinder and (2) that the spark of a secondary coil were employed in my original plan of 1864, which I candidly described as a "compilation." The real secrets, however, of my success were (1) the spinning of the cylinder "as a gyroscope" with a view to secure *perfect smoothness* of motion, (2) the contrivance of means for measuring the *varying motion* of the cylinder, and (3) the invention of a proper form of screen. Unfortunately the Ordnance Select Committee in 1864 entertained a strong objection to any rival of their pet Navez, and, in particular, to all chronographs with "rotating cylinders."* But when they had in their hands *Reports* I. and II. of my experiments, dated respectively December, 1865, and October, 1866,† containing abundant evidence of the practical success of the rotating cylinder employed in my instrument, the Committee thought it fit and becoming shortly afterwards to bring forward the Noble Chronograph, which was, in fact, a very poor imitation of my instrument, only it must be borne in mind that I used neither toothed wheels to drive the cylinder nor yet a stop-clock to measure its angular velocity. Under these circumstances I could have had no hesitation in entering on a competitive trial with my instrument as originally constructed. But in order to adapt the principle of my chronograph to measure, in the most satisfactory manner possible, extremely short intervals of time, I had the machine constructed which is represented in fig. 16. The whole change in the original instrument was about equivalent to the addition of a seconds dial to a clock which previously indicated only hours and minutes.

The short cylinder F' about 33 inches in diameter is mounted on a vertical axis C, which is driven in the manner shewn in fig. 16. The endless band passes round the pulley E shewn in plan and section in fig. 17. F is a fixed centre supporting one end of the axis C of the cylinder F'. D is a pall moving freely about its pivot. When the pulley E is spun the heavy end of D has a tendency to fly outwards, so that the other end catches in a notch in the axis C and drives the cylinder F'. When this cylinder has attained its required velocity the driving power is stopped, and the axis C, now moving faster than the pulley E, pushes the pall D out of the way, and thus the cylinder F' is left spinning "as a gyroscope" under the retarding forces of the friction at the pivots, and the resistance of the air. Its motion will then be free from vibration and perfectly steady, so that the loss of its angular velocity must follow some *simple law*. If it be afterwards found desirable to increase the angular velocity of F', by turning the handle in the right direction, the pall D will be caused to catch the notch in C, and so drive the cylinder till the required velocity is attained. Any other driving arrangement might be used, provided it did not impart a vibratory motion to the frame and was capable of being *completely detached* from C before the experiment was made.

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* *Proceedings of the Ordnance Select Committee*, 1862, p. 15.

† *Reports, &c.*, p. 1—17.

The records are received on paper stretched upon the cylinder F'. They are made by sparks discharged at the point P from one or more secondary coils. In cases where the records are required to succeed each other at intervals less than $\frac{1}{20}$th of a second it will be necessary to use several independent primary coils, generally as many coils as there are records to be made. This is in itself a disadvantage, but there does not appear to be any remedy. If now, with a view to obtain all the discharges from one point, one end of each secondary coil were attached at A, and all the remaining ends at B, it is very probable that no record whatever would be obtained at P. For suppose two coils a, b to be so connected as shewn in fig. 18. When the primary wire of a was broken, it is quite probable that the secondary discharge would not take place directly from A to B, but through b to B, which course affords a continuous metallic circuit. So also when the primary current of b was ruptured, the secondary discharge would take place from A to B through a, and not directly from A to B. If, however, we make breaks in the secondary circuits as at c, d (fig. 19) we may render the resistance of the direct course from A to B less than that of any other. This arrangement was tried with two coils, and proved quite satisfactory. There is no doubt it would answer equally well for any number of coils.

It is plain that the angular velocity of the cylinder F' could not vary sensibly during the short time an experiment was in progress. The distances between the records would therefore shew the *relative* intervals at which the primary currents were actually cut, abstraction being made of the errors to which the records made with the spark are known to be liable.

In order to find the *absolute* intervals of time between the records it would be necessary for the exact velocity of the fly wheel to be known at the instant when the experiment was made. This is satisfactorily provided for as follows. The chronograph shewn in the frontispiece is used to measure the time of every revolution of the cylinder F'. For this purpose a short arm attached to the axis C interrupts, once for every complete revolution, the galvanic current connected with the electro-magnet E. In order to shew during what particular revolution the experiment was made, one or more of the secondary circuits is arranged to give a record near the markers m, m'. This record serves to *point out* the particular revolution required, and knowing the exact times of several successive revolutions before and after, we can calculate the exact motion of the cylinder F' at the instant when the records were made. If necessary, it would be possible to calculate the varying motion of the cylinder during the progress of the experiment.

As I have already remarked (Art. 11), the great drawbacks to the use of such an instrument in ballistic experiments are (1) the uncertain action of the spark as a recording agent, and (2) the impossibility of securing accuracy in space. When the successive intervals of time to be measured are subject to rapid variation, as in determining the motion of a shot in the bore of a gun, such an instrument is perfectly powerless, and at present I cannot think of any practical case in which it could be used advantageously. As, however, I found that Captain Andrew Noble, in conjunction with the Committee on Explosives, was employing the principles of my chronograph not only to an improper purpose, but also in a most rude and unscientific manner, I felt it to be my duty, in consequence of my official position, to explain clearly how to obtain the best possible result. In order to shew how little novelty there was in the Noble Chronograph, I offered (March 20, 1869) to place my original chronograph in the same circuit with it, using the fly wheel as my rotating cylinder to obtain a sufficient velocity of rotation. My chronograph was reported ready for the competitive trial offered me May 28, 1870, in the following terms: "The chronograph has been "removed from Shoeburyness, and is now ready for the inspection of the "gentlemen who are to examine into the comparative merits of my chronograph and that subsequently brought forward by Captain Andrew Noble "*when applied under like circumstances to any experiment whatever*."*

It will be seen that I was careful not to offer to determine the motion of a shot in the bore of a gun by means of a chronograph, which I believe to be an impossibility, and therefore I consider it an absurdity to attempt it. But by putting both instruments into the same circuits the results would have been free from any question about the precise time when the primaries were cut, that is, from any question about accuracy of *space*. The real trial would thus have been limited to the comparative merits of the two chronographs as measurers of very *short intervals of time*. To my regret the competitive trial did not take place, for, if the records of the two instruments had been *read off* and *reduced* by competent mathematicians, the true value of such instruments as the Committee on Explosives have been using would have been authoritatively settled. But if this question had been decided in favour of one or both the chronographs, before the results of the experiments of the Committee on Explosives could be accepted as conclusive, there would remain the question whether the shearing instrument employed by them, and represented in fig. 4, could be expected to secure sufficient accuracy in the intervals of *space* to allow the rapidly varying pressure of fired gunpowder to be accurately calculated.

The following is a statement of the times in which a few successive revolutions of the cylinder F' were made in a trial experiment:

No. of Revolutions.	Time seconds.	seconds. Δ_1	Δ_2
23	13·352		
		+ 0·550	
24	13·902		+ ·001
		+ ·551	
25	14·453		+ ·003
		+ ·554	
26	15·007		+ ·003
		+ ·557	
27	15·564		+ ·004
		+ ·561	
28	16·125		+ ·002
		+ ·563	
29	16·688		+ ·003
		+ ·566	
30	17·254		+ ·003
		+ ·569	
31	17·823		+ ·003
		+ ·572	
32	18·395		+ ·003
		+ ·575	
33	18·970		+ ·003
		+ ·578	
34	19·548		+ ·002
		+ ·580	
35	20·128		+ ·004
		+ ·584	
36	20·712		+ ·004
		+ ·588	
37	21·300		
&c.	&c.		

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* *Reports, &c.*, p. 162.

In order to determine the value of the spark from the secondary coil as a recording agent the following experiments were made. The discharging point P (fig. 16) was caused to move accurately in a line parallel to the axis of the cylinder F'. The primary current of the coil was arranged so that it was momentarily interrupted at every complete revolution of the cylinder F'. Consequently the secondary sparks discharged from P ought to have given records arranged in a straight line. When the cylinder was stationary, a tracer, attached to the same frame as P, was used to mark a line on the paper. The distances of all the records were measured carefully from this line as a base, and then their mean was found. Afterwards the difference between this mean and each reading was taken as the error of that reading. The sum of the numerical values of these errors was divided by the number of records to obtain the mean error. The velocity of the surface of the cylinder on which the records were made was about 300 inches per second and under.

Experiment I. The successive errors were + ·010, - ·003, + ·013, ·000, - ·004, - ·018, + ·006, &c., giving the mean error of 34 records = 0·0107 inch.

Experiment II. The successive errors were + ·001, - ·020, - ·048, - ·012, + ·020, + ·006, &c., giving the mean error of 32 records = 0·0112 inch.

Experiment III. The successive errors were + ·006, + ·012, ·000, + ·020, + ·008, - ·006, &c., giving the mean error of 26 records = 0·0118 inch.

Numerous other trials of the same kind were made, but the general results were manifestly the same as those given above, no matter which pole was attached to the discharging point.

In the next place, the marker m, in the instrument shewn in the frontispiece, was replaced by a discharging point properly connected with a secondary coil. The fly-wheel was then spun as a gyroscope, and, the primary current being rapidly interrupted in the usual manner, the records on the cylinder ought to have ranged in a spiral line. In this case the *lateral deviations* of 100 successive records were measured, and the mean was found to be 0·0075 inch. In this case the error may have been in some slight degree due to the motion of the paper, which was moving at the rate of not more than 10 inches per second.

Lastly, the cylinder F' (fig. 16) was kept perfectly stationary. While the primary current was being rapidly interrupted in the usual manner, the discharging point P was caused to move parallel to the axis of the cylinder. The mean error of 46 successive records so obtained was found to be 0·0069 inch.

II.

DESCRIPTION OF A GRAVITY CHRONOGRAPH.

AFTER having made preliminary experiments, I expressed an opinion* that the ballistic instruments of Navez, Leurs, Boulengé, &c., might be replaced for ordinary purposes by a simpler, cheaper, and more reliable instrument. Shortly afterwards I received several communications on the subject from the War Office. The carrying out of my plans proved more troublesome than I at first expected, and, as my time was then fully occupied by experiments on the resistance of the air to the motion of projectiles, I was not disposed to allow my attention to be diverted from that important work merely to perfect an instrument to which no scientific interest was attached. When, however, the reports on those experiments had been sent in, I enquired whether a simple form of my chronograph was still required. Being encouraged to proceed with my invention, and seeing no reason why the simple form of instrument should not succeed, I felt obliged to persevere.

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* *Philosophical Transactions*, 1868, p. 419.

Although the original instrument, shewn in the frontispiece, would have given results of extreme accuracy, yet the exact reduction of each round would have been attended with a great waste of labour. After much trouble the original scheme for a simple form of chronograph was made perfectly successful, which was dependent on a time scale given by a body *falling freely* through a given height. The firing of the gun was so timed that the records of the two end screens were nearly equidistant from the time records. Thus A, B are the records of the beginning and end of the time, generally half-a-second; and a, b, c, d are the records given by four equidistant screens. Aa must be made nearly equal to dB.

$$\dot{A} \qquad\qquad \dot{a} \qquad\quad \dot{b} \qquad\quad \dot{c} \qquad\quad \dot{d} \qquad\qquad \dot{B}$$

The records are received on a vertical cylinder K, the motion of which is regulated by a fly-wheel A, as shewn in the frontispiece. As the stage S is now stationary for each experiment, there is no necessity for the lowering machinery MCD; and the slide L may be made of wood. There is only one electro-magnet E, and one marker m, which is used to give both the time and screen records. The cylinder K is about 9 inches in diameter, and the speed must be such that the distance AB representing half-a-second may be from 15 to 20 inches.

The arrangement for dropping the ball W, which gives the scale of time, is shewn in fig. 11. The wires C_1, C_2 must be connected with the wires + and − of the electro-magnet E, shewn in the frontispiece. A wire must be carried from B_1 to the galvanic battery, to the arrangement for dropping the weight by which the gun is fired, through three or more screens constructed as shewn in fig. 12, when arranged at equal distances as shewn in fig. 13, and finally connected with B_2. The galvanic circuit is completed as follows, when arrangements have been made for firing a round: through the screens, &c., to B_2, h, i, g, f, d, e, c, b, a, v, u, coil of the electro-magnet D, r, o, B_1.

The firing of the gun is caused by the fall of a weight. When the weight is dropped a momentary interruption of the above galvanic current is caused. The height through which the body falls before it fires the gun requires to be adjusted so as to throw the screen records a, b, c, d in the proper position relatively to the time records A, B.

The instrument is represented in fig. 11, ready prepared for the firing of a round, the electro-magnet E of the chronograph being excluded from the galvanic circuit. When the weight intended to fire the gun is liberated, the momentary interruption of the galvanic current destroys the magnetism in D, and the lever OA, having nothing to support it, begins to fall by turning about its pivot O. The switch descends from the position ot to ot', and so turns the galvanic current into the course B_1, o, s, C_1, *through the chronograph*, C_2, w, a, b', c, e, d, f, g, &c. When the lever OA comes into the vertical position OA', it strikes a projection on the bolt eA', and thus suddenly withdraws, would require regulating with the greatest nicety. If any one of the four became unduly strong, one velocity would be vitiated, and then how would it be possible to decide which of the two results was the correct one? As the number of such instruments as those of Navez, Leurs, Boulengé, &c., is increased, the liability to discordant results is also increased.

III.

ON INTERPOLATION AND QUADRATURES.

WE have already seen (Art. 54) that

$$u_{x+nl} = u_x + \frac{n}{1}\,\Delta u_x + \frac{n\,(n-1)}{1.2}\,\Delta^2 u_x + \frac{n\,(n-1)\,(n-2)}{1.2.3}\,\Delta^3 u_x + \&\text{c.} \ldots \text{I.}$$

Also

$$u_{x-l} = u_x - \Delta u_{x-l},$$

$$u_{x-2l} = u_{x-l} - \Delta u_{x-2l} = u_x - \Delta u_{x-l} - \Delta\,(u_{x-l} - \Delta u_{x-2l}),$$

$$= u_x - 2\Delta u_{x-l} + \Delta^2 u_{x-2l},$$

$$u_{x-3l} = u_x - 3\Delta u_{x-l} + 3\Delta^2 u_{x-2l} - \Delta^3 u_{x-3l},$$

&c. = &c.

$$u_{x-nl} = u_x - \frac{n}{1}\,\Delta u_{x-l} + \frac{n\,(n-1)}{1.2}\,\Delta^2 u_{x-2l} - \frac{n\,(n-1)\,(n-2)}{1.2.3}\,\Delta^3 u_{x-3l} + \&\text{c} \ldots \text{II.}$$

Putting $n = \frac{1}{2}$ in I. and II. we have

$$u_{x+\frac{1}{2}l} = u_x + \tfrac{1}{2}\Delta u_x - \tfrac{1}{8}\Delta^2 u_x + \tfrac{1}{16}\Delta^3 u_x - \tfrac{5}{128}\Delta^4 u_x + \tfrac{7}{256}\Delta^5 u_x - \&\text{c.} \ldots (a),$$

and

$$u_{x-\frac{1}{2}l} = u_x - \tfrac{1}{2}\Delta u_{x-l} - \tfrac{1}{8}\Delta^2 u_{x-2l} - \tfrac{1}{16}\Delta^3 u_{x-3l} - \tfrac{5}{128}\Delta^4 u_{x-4l} - \tfrac{7}{256}\Delta^5 u_{x-5l} - \&\text{c.} \ldots (b).$$

Thus, in Art. 55, we find by interpolation the proper place of beat 3.5 seconds, for

by (*a*) $u_{3\cdot5} = u_3 + \frac{1}{2}\Delta u_3 - \frac{1}{8}\Delta^2 u_3 + \frac{1}{16}\Delta^3 u_3$

$= 73\cdot637 + \frac{1}{2} \times 23\cdot794 + \frac{1}{8} \times \cdot054 - \frac{1}{16} \times \cdot003 = 85\cdot541.$

or by (*b*) $u_{3\cdot5} = u_4 - \frac{1}{2}\Delta u_3 - \frac{1}{8}\Delta^2 u_2 - \frac{1}{16}\Delta^3 u_1$

$= 97\cdot431 - \frac{1}{2} \times 23\cdot794 + \frac{1}{8} \times \cdot051 + \frac{1}{16} \times \cdot003 = 85\cdot541.$

Again, if after having completed the interpolations for half-seconds, we desire to find the readings corresponding to the one-tenth of a second, or to the one-fifth of half-a-second,

$$n = \tfrac{1}{5},\ u_{x+\frac{1}{5}l} = u_x + \tfrac{1}{5}\Delta u_x - \tfrac{2}{25}\Delta^2 u_x + \tfrac{6}{125}\Delta^3 u_x - \tfrac{21}{625}\Delta^4 u_x + \&\text{c.} \ldots (c_1),$$

$$n = \tfrac{2}{5},\ u_{x+\frac{2}{5}l} = u_x + \tfrac{2}{5}\Delta u_x - \tfrac{3}{25}\Delta^2 u_x + \tfrac{8}{125}\Delta^3 u_x - \tfrac{26}{625}\Delta^4 u_x + \&\text{c.} \ldots (c_2),$$

&c. = &c.

Also

$$u_{x-\frac{1}{5}l} = u_x - \tfrac{1}{5}\Delta u_{x-l} - \tfrac{2}{25}\Delta^2 u_{x-2l} - \tfrac{6}{125}\Delta^3 u_{x-3l} - \tfrac{21}{625}\Delta^4 u_{x-4l} - \&\text{c.} \ldots (d_1),$$

$$u_{x-\frac{2}{5}l} = u_x - \tfrac{2}{5}\Delta u_{x-l} - \tfrac{3}{25}\Delta^2 u_{x-2l} - \tfrac{8}{125}\Delta^3 u_{x-3l} - \tfrac{26}{625}\Delta^4 u_{x-4l} - \&\text{c.} \ldots (d_2),$$

&c. = &c.

Supposing the divisions corresponding to the half-seconds to be known in Art. 55, let us find the divisions corresponding to 4·2 and 4·3 seconds.

By formula (c_2) $u_{4\cdot 2} = 97{\cdot}431 + \frac{2}{5} \times 11{\cdot}877 + \frac{3}{25} \times {\cdot}014 = 102{\cdot}184$,

and by formula (d_2) $u_{4\cdot 3} = 109{\cdot}308 - \frac{2}{5} \times 11{\cdot}877 + \frac{3}{25} \times {\cdot}014 = 104{\cdot}559$.

It will be observed that the quantities u_x, Δu_x, $\Delta^2 u_x$, $\Delta^3 u_x$, &c., used in I., are arranged in a diagonal line pointing *downwards* from u_x in the scheme at page 39, and also that the quantities u_x, Δu_{x-l}, $\Delta^2 u_{x-2l}$, $\Delta^3 u_{x-3l}$, &c., used in II., are arranged in a diagonal line pointing *upwards*. We can replace these formulæ by two others depending upon the terms

$$u_x \begin{array}{l} + \Delta u_{x-l} \\ + \Delta u_x \end{array} + \Delta^2 u_{x-l} \begin{array}{l} + \Delta^3 u_{x-2l} \\ + \Delta^3 u_{x-l} \end{array} + \Delta^4 u_{x-2l} \begin{array}{l} + \Delta^5 u_{x-3l} \\ + \Delta^5 u_{x-2l} \end{array} + \Delta^6 u_{x-3l} \begin{array}{l} + \Delta^7 u_{x-4l} \\ + \Delta^7 u_{x-3l} \end{array} + \Delta^8 u_{x-4l}.$$

Since $u_x = u_{x-l} + \Delta u_{x-l}$,

$$\Delta^2 u_x = \Delta^2 u_{x-l} + \Delta^3 u_{x-l},$$

$$\Delta^3 u_x = \Delta^3 u_{x-l} + \Delta^4 u_{x-2l} + \Delta^5 u_{x-2l},$$

$$\Delta^4 u_x = \Delta^4 u_{x-2l} + 2\Delta^5 u_{x-2l} + \Delta^6 u_{x-3l} + \Delta^7 u_{x-3l},$$

$$\Delta^5 u_x = \Delta^5 u_{x-2l} + 2\Delta^6 u_{x-3l} + 3\Delta^7 u_{x-3l} + \Delta^8 u_{x-4l} + \Delta^9 u_{x-4l},$$

$$\Delta^6 u_x = \Delta^6 u_{x-3l} + 3\Delta^7 u_{x-3l} + \&c.,$$

$$\&c. = \quad \&c.$$

Substituting now these values of $\Delta^2 u_x$, $\Delta^3 u_x$, &c., in I., we get

$$u_{x+nl} = u_x + \frac{n}{1} \Delta u_x + \frac{n(n-1)}{1.2} \Delta^2 u_{x-l} + \frac{(n+1)n(n-1)}{1.2.3} \Delta^3 u_{x-l}$$

$$+ \frac{(n+1)n(n-1)(n-2)}{1.2.3.4} \Delta^4 u_{x-2l} + \frac{(n+2)(n+1)n(n-1)(n-2)}{1.2.3.4.5} \Delta^5 u_{x-2l}$$

$$+ \frac{(n+2)(n+1)n(n-1)(n-2)(n-3)}{1.2.3.4.5.6} \Delta^6 u_{x-3l} + \&c. \ldots\ldots\ldots\ldots\ldots \text{III.}$$

Or, expressing the values of $\Delta^2 u_{x-2l}$, $\Delta^3 u_{x-3l}$, &c., in terms of $\Delta^2 u_{x-l}$, $\Delta^3 u_{x-2l}$, &c., and substituting in II., we shall find

$$u_{x-nl} = u_x - \frac{n}{1} \Delta u_{x-l} + \frac{n(n-1)}{1.2} \Delta^2 u_{x-l} - \frac{(n+1)n(n-1)}{1.2.3} \Delta^3 u_{x-2l}$$

$$+ \frac{(n+1)n(n-1)(n-2)}{1.2.3.4} \Delta^4 u_{x-2l} - \frac{(n+2)(n+1)n(n-1)(n-2)}{1.2.3.4.5} \Delta^5 u_{x-3l}$$

$$+ \frac{(n+2)(n+1)n(n-1)(n-2)(n-3)}{1.2.3.4.5.6} \Delta^6 u_{x-3l} - \&c. \ldots\ldots\ldots\ldots\ldots \text{IV.}$$

It thus appears that having obtained values of $\ldots u_{x-l}, u_x, u_{x+l}, \ldots$&c., by calculation or observation, we are able to express the value of u_{x+nl} from u_{x-l} to u_{x+l}, or, more correctly, from $u_{x-\frac{1}{2}l}$ to $u_{x+\frac{1}{2}l}$, which is all that is really needed.

By the help of the preceding formulæ of interpolation we are enabled to obtain the *numerical* values of integrals of functions which cannot be integrated in the ordinary way. Suppose y_x to be the ordinate of a curve corresponding to the abscissa x. Then the area bounded by the curve, the axis of x, and the ordinates at the distances a and $a+l$, will be equal to ${}^{a}\!\int^{a+l} y_x dx = {}^{0}\!\int^{1} y_{a+nl}\, dnl = {}^{0}\!\int^{1} l y_{a+nl}\, dn = {}^{0}\!\int^{1} u_{a+nl}\, dn$, suppose,

$$= {}^{0}\!\int^{1} \left(u_a + \frac{n}{1} \Delta u_a + \frac{n(n-1)}{1.2} \Delta^2 u_a + \frac{n(n-1)(n-2)}{1.2.3} \Delta^3 u_a + \&c. \right) dn$$

$$= u_a + \tfrac{1}{2} \Delta u_a - \tfrac{1}{12} \Delta^2 u_a + \tfrac{1}{24} \Delta^3 u_a - \tfrac{19}{720} \Delta^4 u_a$$

$$+ \tfrac{3}{160} \Delta^5 u_a - \tfrac{863}{60480} \Delta^6 u_a + \&c. \ldots\ldots\ldots\ldots\ldots\ldots \text{V.}$$

In the same manner we may find the area of the curve enclosed between the ordinates y_{a+l} and y_{a+2l}; between y_{a+2l} and y_{a+3l}; and so on. And taking the sums of these partial areas we find the area of the curve enclosed by ordinates at the distances a and $a+rl$ where r is any integer. But this method, applied in the first instance to find the areas of curves, may be used to find the values of the integrals of any continuous functions between limits.

The above formula (V.) was employed in the calculation of the tabular values of X, Y, and T. Each of these quantities is a function of γ and ϕ. A numerical value was given to γ, and then ϕ was made in succession $0, +1°, +2°, +3°$, &c., and $0, -1°, -2°, -3° \ldots -45°$. The value of l or $d\phi$ was the circular measure of one degree. But, when the values of u_ϕ became irregular, $l = d\phi$ was made equal to the circular measure of $\frac{1}{6}$th of a degree. In this way the values of Δu, $\Delta^2 u$, &c., were made to decrease rapidly, which allowed the formula (V.) to be used in spite of the slow convergence of the coefficients.

Another formula may be deduced from III.

$${}^{a-\frac{1}{2}l}\!\int^{a+\frac{1}{2}l} y_x dx = {}^{-\frac{1}{2}}\!\int^{+\frac{1}{2}} l y_{a+nl}\, dn = {}^{-\frac{1}{2}}\!\int^{+\frac{1}{2}} u_{a+nl}\, dn$$

$$= {}^{-\frac{1}{2}}\!\int^{+\frac{1}{2}} \left\{ u_a + \frac{n}{1} \Delta u_a + \frac{n(n-1)}{1.2} \Delta^2 u_{a-l} + \frac{(n+1)n(n-1)}{1.2.3} \Delta^3 u_{a-l} + \&c. \right\} dn$$

$$= u_a + \tfrac{1}{24} \Delta^2 u_{a-l} - \tfrac{17}{5760} \Delta^4 u_{a-2l} + \tfrac{367}{967680} \Delta^6 u_{a-3l} - \&c.$$

ERRATA.

Page 40, formula (2), *for* "$\frac{12}{90}$," *read* "$\frac{1}{90}$."

" 14, Tables, *for* ${}^{43}\boldsymbol{Y}_{\cdot 02}{}^{0}$ = "·676277," *read* "·677277."

I. COEFFICIENTS FOR THE CUBIC LAW OF RESISTANCE.

ELONGATED PROJECTILES WITH OGIVAL HEADS.

(Reports &c. p. 152.)

v	K_v	$\frac{K_v}{g}$	Log $\frac{K_v}{g}$	v	K_v	$\frac{K_v}{g}$	Log $\frac{K_v}{g}$
f-s				f-s			
900	64.4	2.001	.3012	1300	107.9	3.352	.5253
910	64.8	2.014	.3041	1310	107.7	3.345	.5244
920	65.3	2.029	.3073	1320	107.4	3.337	.5234
930	65.9	2.047	.3111	1330	107.1	3.328	.5222
940	66.6	2.069	.3158	1340	106.8	3.317	.5207
950	67.4	2.094	.3210	1350	106.4	3.305	.5192
960	68.4	2.125	.3274	1360	106.0	3.293	.5176
970	69.6	2.162	.3349	1370	105.6	3.280	.5159
980	71.0	2.206	.3436	1380	105.1	3.265	.5139
990	72.8	2.262	.3545	1390	104.6	3.249	.5118
1000	75.0	2.330	.3674	1400	104.0	3.231	.5093
1010	77.5	2.408	.3817	1410	103.4	3.212	.5068
1020	80.4	2.498	.3976	1420	102.8	3.193	.5042
1030	83.9	2.606	.4160	1430	102.2	3.175	.5017
1040	88.2	2.740	.4378	1440	101.6	3.155	.4990
1050	92.8	2.883	.4598	1450	100.9	3.134	.4961
1060	97.2	3.019	.4799	1460	100.2	3.112	.4930
1070	100.8	3.131	.4957	1470	99.4	3.089	.4898
1080	103.4	3.212	.5068	1480	98.7	3.065	.4864
1090	105.1	3.265	.5139	1490	97.9	3.041	.4830
1100	106.0	3.293	.5176	1500	97.2	3.018	.4797
1110	106.6	3.312	.5201	1510	96.4	2.994	.4763
1120	107.1	3.327	.5221	1520	95.5	2.968	.4725
1130	107.5	3.339	.5236	1530	94.7	2.942	.4686
1140	107.9	3.351	.5252	1540	93.8	2.915	.4646
1150	108.2	3.361	.5265	1550	93.0	2.889	.4607
1160	108.5	3.371	.5278	1560	92.2	2.864	.4570
1170	108.7	3.377	.5285	1570	91.4	2.839	.4532
1180	108.9	3.381	.5290	1580	90.6	2.814	.4493
1190	108.9	3.383	.5293	1590	89.8	2.790	.4456
1200	108.9	3.383	.5293	1600	89.0	2.765	.4417
1210	108.9	3.383	.5293	1610	88.2	2.740	.4378
1220	108.9	3.382	.5292	1620	87.4	2.715	.4338
1230	108.8	3.381	.5290	1630	86.7	2.693	.4302
1240	108.8	3.380	.5289	1640	86.0	2.672	.4268
1250	108.7	3.378	.5287	1650	85.4	2.654	.4239
1260	108.6	3.375	.5283	1660	85.0	2.640	.4216
1270	108.5	3.370	.5276	1670	84.6	2.628	.4196
1280	108.3	3.364	.5269	1680	84.3	2.619	.4181
1290	108.1	3.358	.5261	1690	84.1	2.613	.4171
1300	107.9	3.352	.5253	1700	83.9	2.606	.4160

II. COEFFICIENTS FOR THE CUBIC LAW OF RESISTANCE.

SPHERICAL PROJECTILES.

Reports &c. p. 114.

v	K_v	$\frac{K_v}{g}$	Log $\frac{K_v}{g}$	v	K_v	$\frac{K_v}{g}$	Log $\frac{K_v}{g}$
f-s				f-s			
850	138.4	4.299	.6334	1250	151.1	4.694	.6715
860	138.3	4.296	.6331	1260	150.5	4.674	.6697
870	138.3	4.294	.6329	1270	149.8	4.654	.6678
880	138.2	4.293	.6328	1280	149.1	4.632	.6659
890	138.2	4.293	.6328	1290	148.4	4.611	.6638
900	138.2	4.294	.6329	1300	147.8	4.591	.6619
910	138.3	4.296	.6331	1310	147.2	4.572	.6601
920	138.4	4.299	.6334	1320	146.5	4.552	.6582
930	138.5	4.302	.6337	1330	145.9	4.533	.6564
940	138.6	4.306	.6341	1340	145.3	4.514	.6546
950	138.8	4.312	.6347	1350	144.7	4.495	.6527
960	139.1	4.322	.6357	1360	144.1	4.475	.6508
970	139.5	4.334	.6369	1370	143.4	4.455	.6489
980	139.9	4.346	.6381	1380	142.7	4.433	.6467
990	140.4	4.362	.6397	1390	142.0	4.410	.6444
1000	141.1	4.383	.6418	1400	141.3	4.388	.6423
1010	141.9	4.408	.6442	1410	140.6	4.366	.6401
1020	142.8	4.436	.6470	1420	139.8	4.343	.6378
1030	143.8	4.467	.6500	1430	139.1	4.320	.6355
1040	144.9	4.501	.6533	1440	138.4	4.299	.6334
1050	146.1	4.539	.6570	1450	137.7	4.277	.6311
1060	147.3	4.576	.6605	1460	137.0	4.254	.6288
1070	148.5	4.613	.6640	1470	136.2	4.231	.6264
1080	149.6	4.647	.6672	1480	135.5	4.209	.6242
1090	150.6	4.677	.6700	1490	134.8	4.188	.6220
1100	151.4	4.703	.6724	1500	134.1	4.166	.6197
1110	152.1	4.725	.6744	1510	133.5	4.146	.6176
1120	152.7	4.744	.6762	1520	132.8	4.125	.6154
1130	153.1	4.757	.6773	1530	132.1	4.105	.6133
1140	153.4	4.766	.6782	1540	131.5	4.085	.6112
1150	153.6	4.772	.6787	1550	130.8	4 064	.6090
1160	153.7	4.774	.6789	1560	130.1	4.043	.6067
1170	153.7	4.775	.6790	1570	129.5	4.023	.6046
1180	153.7	4.774	.6789	1580	128.8	4.003	.6024
1190	153.6	4.771	.6786	1590	128.2	3.983	.6002
1200	153.4	4.765	.6781	1600	127.5	3.961	.5978
1210	153.1	4.756	.6772	1610	126.8	3.940	.5955
1220	152.7	4.744	.6762	1620	126.2	3.920	.5933
1230	152.2	4.728	.6747	1630	125.5	3.899	.5910
[illegible]	[illegible]	4.712	.6732	1640	124.8	3.877	.5885
[illegible]	[illegible]	4.694	.6715	1650	124.1	3,856	.5861

v	K_v	$\frac{K_v}{g}$	$\text{Log}\,\frac{K_v}{g}$	v	K_v	$\frac{K_v}{g}$	$\text{Log}\,\frac{K_v}{g}$
f-s				f-s			
1650	124.1	3.856	.5861	1900	108.7	3.377	.5285
1660	123.5	3.836	.5839	1910	108.2	3.361	.5265
1670	122.8	3.815	.5815	1920	107.7	3.346	.5245
1680	122.1	3.793	.5790	1930	107.3	3.332	.5227
1690	121.4	3.772	.5766	1940	106.8	3.317	.5208
1700	120.8	3.752	.5743	1950	106.3	3.302	.5188
1710	120.1	3.731	.5718	1960	105.8	3.287	.5168
1720	119.4	3.710	.5694	1970	105.3	3.272	.5148
1730	118.8	3.689	.5669	1980	104.9	3.258	.5130
1740	118.1	3.669	.5646	1990	104.4	3.243	.5110
1750	117.4	3.648	.5621	2000	103.9	3.228	.5089
1760	116.8	3.628	.5597	2010	103.4	3.212	.5068
1770	116.1	3.608	.5573	2020	102.9	3.197	.5047
1780	115.5	3.588	.5549	2030	102.5	3.183	.5028
1790	114.9	3.568	.5524	2040	102.0	3.169	.5009
1800	114.2	3.548	.5500	2050	101.5	3.154	.4989
1810	113.6	3.529	.5477	2060	101.1	3.140	.4969
1820	113.0	3.511	.5454	2070	100.6	3.125	.4949
1830	112.5	3.494	.5433	2080	100.1	3.110	.4928
1840	111.9	3.476	.5411	2090	99.7	3.096	.4908
1850	111.3	3.459	.5390	2100	99.2	3.081	.4887
1860	110.8	3.442	.5368	2110	98.7	3.066	.4866
1870	110.3	3.425	.5347	2120	98.3	3.053	.4847
1880	109.7	3.408	.5325	2130	97.8	3.039	.4827
1890	109.2	3.392	.5305	2140	97.4	3.025	.4807
1900	108.7	3.377	.5285	2150	96.9	3.010	.4786

III. $\text{Log}\,P_\varphi = \text{Log}\,(3 \tan \varphi + \tan^3 \varphi)$.

φ	$\text{Log}\,P_\varphi$	φ	$\text{Log}\,P_\varphi$	φ	$\text{Log}\,P_\varphi$	φ	$\text{Log}\,P_\varphi$
1°	8.71909	16°	9.94636	31°	0.30525	46°	0.62501
2	9.02038	17	9.97579	32	0.32605	47	0.64839
3	9.19691	18	0.00392	33	0.34676	48	0.67226
4	9.32247	19	0.03093	34	0.36743	49	0.69666
5	9.42018	20	0.05695	35	0.38809	50	0.72164
6	9.50034	21	0.08212	36	0.40877	51	0.74725
7	9.56844	22	0.10654	37	0.42952	52	0.77355
8	9.62777	23	0.13030	38	0.45037	53	0.80059
9	9.68045	24	0.15349	39	0.47135	54	0.82844
10	9.72792	25	0.17618	40	0.49250	55	0.85717
11	9.77121	26	0.19844	41	0.51385	56	0.88685
12	9.81109	27	0.22033	42	0.53545	57	0.91755
13	9.84813	28	0.24191	43	0.55732	58	0.94937
14	9.88280	29	0.26322	44	0.57951	59	0.9823
15	9.91545	30	0.28432	45	0.60206	60	1.016

IV. VALUES OF X, Y & T FOR INTERVALS OF 0°.2.

γ = 0,00				γ = 0,01			
φ	X	Y	T	φ	X	Y	T
60°.0	1.73205	1.50000	1.73205	60°.0	1.77949	1.55885	1.75552
59.8	1.71818	1.47606	1.71818	59.8	1.76457	1.53311	1.74112
59.6	1.70446	1.45259	1.70446	59.6	1.74984	1.50791	1.72691
59.4	1.69091	1.42959	1.69091	59.4	1.73530	1.48323	1.71288
59.2	1.67752	1.40703	1.67752	59.2	1.72096	1.45906	1.69902
59.0	1.66428	1.38492	1.66428	59.0	1.70679	1.43539	1.68533
58.8	1.65120	1.36322	1.65120	58.8	1.69281	1.41221	1.67180
58.6	1.63826	1.34195	1.63826	58.6	1.67899	1.38949	1.65843
58.4	1.62548	1.32109	1.62548	58.4	1.66535	1.36723	1.64523
58.2	1.61283	1.30062	1.61283	58.2	1.65188	1.34542	1.63218
58.0	1.60033	1.28054	1.60033	58.0	1.63857	1.32404	1.61928
57.8	1.58797	1.26083	1.58797	57.8	1.62543	1.30308	1.60653
57.6	1.57575	1.24149	1.57575	57.6	1.61244	1.28253	1.59393
57.4	1.56366	1.22251	1.56366	57.4	1.59960	1.26238	1.58147
57.2	1.55170	1.20388	1.55170	57.2	1.58691	1.24262	1.56915
57.0	1.53987	1.18559	1.53987	57.0	1.57437	1.22324	1.55697
56.8	1.52816	1.16764	1.52816	56.8	1.56198	1.20423	1.54493
56.6	1.51658	1.15001	1.51658	56.6	1.54973	1.18558	1.53302
56.4	1.50512	1.13270	1.50512	56.4	1.53762	1.16728	1.52124
56.2	1.49378	1.11569	1.49378	56.2	1.52564	1.14932	1.50958
56.0	1.48256	1.09899	1.48256	56.0	1.51380	1.13170	1.49806
55.8	1.47146	1.08259	1.47146	55.8	1.50209	1.11440	1.48665
55.6	1.46046	1.06648	1.46046	55.6	1.49051	1.09742	1.47537
55.4	1.44958	1.05065	1.44958	55.4	1.47905	1.08075	1.46420
55.2	1.43881	1.03509	1.43881	55.2	1.46772	1.06438	1.45315
55.0	1.42815	1.01980	1.42815	55.0	1.45651	1.04831	1.44222
54.8	1.41759	1.00478	1.41759	54.8	1.44541	1.03253	1.43140
54.6	1.40714	.99002	1.40714	54.6	1.43444	1.01703	1.42068
54.4	1.39679	.97550	1.39679	54.4	1.42357	1.00180	1.41008
54.2	1.38653	.96124	1.38653	54.2	1.41282	.98684	1.39958
54.0	1.37638	.94722	1.37638	54.0	1.40219	.97214	1.38919
53.8	1.36633	.93343	1.36633	53.8	1.39165	.95770	1.37890
53.6	1.35637	.91987	1.35637	53.6	1.38123	.94351	1.36871
53.4	1.34650	.90653	1.34650	53.4	1.37091	.92956	1.35862
53.2	1.33673	.89342	1.33673	53.2	1.36069	.91585	1.34863
53.0	1.32704	.88052	1.32704	53.0	1.35058	.90238	1.33873
52.8	1.31745	.86783	1.31745	52.8	1.34056	.88914	1.32891
52.6	1.30795	.85536	1.30795	52.6	1.33064	.87612	1.31921
52.4	1.29853	.84309	1.29853	52.4	1.32081	.86332	1.30959
52.2	1.28919	.83102	1.28919	52.2	1.31108	.85073	1.30007
52.0	1.27994	.81913	1.27994	52.0	1.30144	.83834	1.29063
51.8	1.27077	.80743	1.27077	51.8	1.29189	.82616	1.28127
51.6	1.26169	.79592	1.26169	51.6	1.28243	.81418	1.27200
51.4	1.25268	.78460	1.25268	51.4	1.27306	.80240	1.26282
51.2	1.24375	.77346	1.24375	51.2	1.26378	.79081	1.25371

$\gamma = 0.02$				$\gamma = 0.03$			
φ	X	Y	T	φ	X	Y	T
60°.0	1.83254	1.62567	1.78117	60°.0	1.89266	1.70264	1.80950
59.8	1.81636	1.59774	1.76618	59.8	1.87490	1.67200	1.79380
59.6	1.80041	1.57045	1.75139	59.6	1.85743	1.64211	1.77832
59.4	1.78468	1.54376	1.73680	59.4	1.84025	1.61294	1.76306
59.2	1.76919	1.51766	1.72239	59.2	1.82334	1.58447	1.74802
59.0	1.75391	1.49213	1.70817	59.0	1.80671	1.55667	1.73318
58.8	1.73885	1.46716	1.69413	58.8	1.79033	1.52952	1.71854
58.6	1.72399	1.44273	1.68027	58.6	1.77421	1.50301	1.70410
58.4	1.70934	1.41882	1.66658	58.4	1.75833	1.47710	1.68985
58.2	1.69488	1.39541	1.65306	58.2	1.74270	1.45178	1.67579
58.0	1.68062	1.37250	1.63971	58.0	1.72729	1.42703	1.66191
57.8	1.66655	1.35007	1.62652	57.8	1.71211	1.40283	1.64822
57.6	1.65266	1.32810	1.61349	57.6	1.69716	1.37917	1.63469
57.4	1.63896	1.30658	1.60062	57.4	1.68241	1.35603	1.62134
57.2	1.62542	1.28550	1.58790	57.2	1.66788	1.33339	1.60815
57.0	1.61206	1.26485	1.57533	57.0	1.65355	1.31123	1.59513
56.8	1.59887	1.24461	1.56290	56.8	1.63941	1.28955	1.58227
56.6	1.58584	1.22478	1.55062	56.6	1.62547	1.26833	1.56956
56.4	1.57298	1.20534	1.53847	56.4	1.61172	1.24755	1.55701
56.2	1.56027	1.18628	1.52647	56.2	1.59815	1.22721	1.54461
56.0	1.54771	1.16759	1.51460	56.0	1.58476	1.20728	1.53235
55.8	1.53530	1.14927	1.50286	55.8	1.57154	1.18776	1.52023
55.6	1.52304	1.13130	1.49125	55.6	1.55850	1.16864	1.50826
55.4	1.51093	1.11367	1.47977	55.4	1.54562	1.14990	1.49642
55.2	1.49895	1.09638	1.46841	55.2	1.53291	1.13154	1.48472
55.0	1.48712	1.07941	1.45718	55.0	1.52035	1.11354	1.47315
54.8	1.47542	1.06276	1.44607	54.8	1.50795	1.09589	1.46171
54.6	1.46385	1.04642	1.43507	54.6	1.49570	1.07859	1.45039
54.4	1.45241	1.03038	1.42419	54.4	1.48360	1.06163	1.43920
54.2	1.44109	1.01464	1.41342	54.2	1.47164	1.04499	1.42813
54.0	1.42991	.99918	1.40276	54.0	1.45983	1.02867	1.41718
53.8	1.41884	.98401	1.39221	53.8	1.44815	1.01266	1.40634
53.6	1.40789	.96911	1.38177	53.6	1.43661	.99695	1.39562
53.4	1.39706	.95447	1.37143	53.4	1.42521	.98153	1.38501
53.2	1.38635	.94010	1.36120	53.2	1.41393	.96640	1.37452
53.0	1.37575	.92598	1.35107	53.0	1.40278	.95155	1.36413
52.8	1.36526	.91211	1.34104	52.8	1.39175	.93697	1.35385
52.6	1.35488	.89848	1.33111	52.6	1.38085	.92266	1.34367
52.4	1.34460	.88509	1.32127	52.4	1.37007	.90860	1.33359
52.2	1.33442	.87192	1.31152	52.2	1.35940	.89480	1.32361
52.0	1.32435	.85898	1.30187	52.0	1.34885	.88125	1.31372
51.8	1.31438	.84627	1.29231	51.8	1.33841	.86794	1.30393
51.6	1.30451	.83378	1.28284	51.6	1.32808	.85486	1.29424
51.4	1.29474	.82149	1.27346	51.4	1.31786	.84201	1.28465
51.2	1.28506	.80941	1.26416	51.2	1.30774	.82938	1.27515
51.0	1.27548	.79753	1.25494	51.0	1.29773	.81697	1.26574
50.8	1.26598	.78585	1.24581	50.8	1.28782	.80477	1.25642
50.6	1.25658	.77436	1.23676	50.6	1.27801	.79278	1.24718

γ = 0.04				γ = 0.05			
φ	X	Y	T	φ	X	Y	T
60°.0	1.96194	1.79302	1.84116	60°.0	2.04361	1.90178	1.87718
59.8	1.94216	1.75889	1.82459	59.8	2.02112	1.86297	1.85951
59.6	1.92275	1.72568	1.80828	59.6	1.99913	1.82535	1.84215
59.4	1.90372	1.69336	1.79222	59.4	1.97764	1.78886	1.82509
59.2	1.88503	1.66189	1.77640	59.2	1.95662	1.75346	1.80831
59.0	1.86669	1.63124	1.76082	59.0	1.93605	1.71908	1.79181
58.8	1.84867	1.60138	1.74546	58.8	1.91591	1.68569	1.77557
58.6	1.83097	1.57227	1.73033	58.6	1.89618	1.65325	1.75960
58.4	1.81358	1.54388	1.71542	58.4	1.87685	1.62170	1.74388
58.2	1.79648	1.51620	1.70072	58.2	1.85790	1.59102	1.72840
58.0	1.77967	1.48920	1.68623	58.0	1.83932	1.56116	1.71316
57.8	1.76314	1.46284	1.67193	57.8	1.82108	1.53210	1.69814
57.6	1.74688	1.43712	1.65783	57.6	1.80319	1.50379	1.68336
57.4	1.73088	1.41201	1.64392	57.4	1.78563	1.47622	1.66878
57.2	1.71513	1.38748	1.63020	57.2	1.76838	1.44935	1.65442
57.0	1.69963	1.36351	1.61666	57.0	1.75143	1.42316	1.64026
56.8	1.68437	1.34010	1.60329	56.8	1.73478	1.39762	1.62630
56.6	1.66933	1.31721	1.59010	56.6	1.71842	1.37270	1.61253
56.4	1.65453	1.29484	1.57707	56.4	1.70233	1.34839	1.59895
56.2	1.63994	1.27297	1.56421	56.2	1.68650	1.32466	1.58556
56.0	1.62556	1.25157	1.55151	56.0	1.67093	1.30150	1.57234
55.8	1.61139	1.23064	1.53897	55.8	1.65562	1.27887	1.55930
55.6	1.59742	1.21017	1.52657	55.6	1.64054	1.25677	1.54643
55.4	1.58365	1.19013	1.51433	55.4	1.62570	1.23517	1.53372
55.2	1.57007	1.17051	1.50224	55.2	1.61108	1.21407	1.52117
55.0	1.55667	1.15130	1.49029	55.0	1.59669	1.19344	1.50878
54.8	1.54346	1.13250	1.47847	54.8	1.58251	1.17326	1.49655
54.6	1.53042	1.11408	1.46680	54.6	1.56854	1.15353	1.48446
54.4	1.51755	1.09604	1.45526	54.4	1.55477	1.13423	1.47253
54.2	1.50485	1.07837	1.44385	54.2	1.54120	1.11534	1.46073
54.0	1.49231	1.06105	1.43256	54.0	1.52782	1.09686	1.44908
53.8	1.47994	1.04408	1.42141	53.8	1.51463	1.07877	1.43756
53.6	1.46772	1.02744	1.41038	53.6	1.50162	1.06105	1.42617
53.4	1.45565	1.01113	1.39946	53.4	1.48878	1.04370	1.41492
53.2	1.44373	.99514	1.38867	53.2	1.47612	1.02671	1.40380
53.0	1.43195	.97945	1.37799	53.0	1.46362	1.01007	1.39280
52.8	1.42032	.96406	1.36743	52.8	1.45129	.99376	1.38192
52.6	1.40882	.94897	1.35698	52.6	1.43911	.97778	1.37116
52.4	1.39746	.93417	1.34664	52.4	1.42709	.96212	1.36052
52.2	1.38624	.91965	1.33640	52.2	1.41522	.94676	1.34999
52.0	1.37514	.90540	1.32626	52.0	1.40351	.93171	1.33958
51.8	1.36417	.89141	1.31623	51.8	1.39194	.91695	1.32928
51.6	1.35332	.87768	1.30630	51.6	1.38051	.90247	1.31909
51.4	1.34260	.86420	1.29647	51.4	1.36921	.88827	1.30901
51.2	1.33199	.85095	1.28674	51.2	1.35804	.87434	1.29903
51.0	1.32150	.83795	1.27711	51.0	1.34701	.86067	1.28914
50.8	1.31112	.82518	1.26757	50.8	1.33611	.84726	1.27935
50.6	1.30085	.81264	1.25812	50.6	1.32533	.83410	1.26966

γ = 0.06				γ = 0.07			
φ	X	Y	T	φ	X	Y	T
60.0°	2.14308	2.03739	1.91913	60.0°	2.27039	2.21597	1.96977
59.8	2.11669	1.99187	1.89999	59.8	2.23783	2.15980	1.94851
59.6	2.09106	1.94799	1.88124	59.6	2.20652	2.10621	1.92779
59.4	2.06613	1.90568	1.86286	59.4	2.17634	2.05498	1.90757
59.2	2.04187	1.86482	1.84484	59.2	2.14722	2.00594	1.88782
59.0	2.01825	1.82534	1.82716	59.0	2.11908	1.95891	1 86852
58.8	1.99522	1.78717	1.80980	58.8	2.09184	1.91376	1.84964
58.6	1.97276	1.75023	1.79276	58.6	2.06545	1.87036	1.83117
58.4	1.95084	1.71445	1.77601	58.4	2.03986	1.82859	1.81308
58.2	1.92943	1.67979	1.75956	58.2	2.01501	1.78835	1.79535
58.0	1.90851	1.64619	1.74339	58.0	1.99085	1.74955	1.77798
57.8	1.88806	1.61359	1.72749	57.8	1.96736	1.71209	1.76093
57.6	1.86806	1.58194	1.71186	57.6	1.94448	1.67591	1.74421
57.4	1.84848	1.55121	1.69647	57.4	1.92220	1.64092	1.72780
57.2	1.82931	1.52135	1.68133	57.2	1.90046	1.60707	1.71167
57.0	1.81053	1.49233	1.66642	57.0	1.87926	1.57430	1.69584
56.8	1.79213	1.46410	1.65175	56.8	1.85856	1.54254	1.68027
56.6	1.77409	1.43663	1.63729	56.6	1.83833	1.51175	1.66497
56.4	1.75639	1.40990	1.62306	56.4	1.81857	1.48188	1.64991
56.2	1.73903	1.38386	1.60902	56.2	1.79923	1.45289	1.63511
56.0	1.72199	1.35850	1.59520	56.0	1.78031	1.42473	1.62054
55.8	1.70526	1.33379	1.58156	55.8	1.76179	1.39738	1.60620
55.6	1.68883	1.30970	1.56812	55.6	1.74365	1.37078	1.59207
55.4	1.67268	1.28621	1.55487	55.4	1.72587	1.34491	1.57816
55.2	1.65682	1.26330	1.54180	55.2	1.70844	1.31974	1.56446
55.0	1.64122	1.24094	1.52890	55.0	1.69135	1.29524	1.55096
54.8	1.62588	1.21911	1.51617	54.8	1.67458	1.27138	1.53766
54.6	1.61079	1.19780	1.50361	54.6	1.65812	1.24813	1.52454
54.4	1.59595	1.17699	1.49122	54.4	1.64196	1.22548	1.51161
54.2	1.58134	1.15666	1.47898	54.2	1.62609	1.20339	1.49885
54.0	1.56696	1.13679	1.46690	54.0	1.61049	1.18185	1.48627
53.8	1.55280	1.11738	1.45496	53.8	1.59517	1.16083	1.47386
53.6	1.53885	1.09839	1.44318	53.6	1.58010	1.14032	1.46161
53.4	1.52512	1.07983	1.43154	53.4	1.56529	1.12030	1.44952
53.2	1.51158	1.06167	1.42004	53.2	1.55071	1.10075	1.43758
53.0	1.49824	1.04390	1.40867	53.0	1.53638	1.08165	1.42580
52.8	1.48509	1.02652	1.39744	52.8	1.52227	1.06299	1.41417
52.6	1.47213	1.00950	1.38634	52.6	1.50838	1.04475	1.40268
52.4	1.45935	.99284	1.37537	52.4	1.49470	1.02691	1.39133
52.2	1.44674	.97653	1.36452	52.2	1.48122	1.00948	1.38011
52.0	1.43431	.96056	1.35379	52.0	1.46794	.99244	1.36902
51.8	1.42204	.94491	1.34318	51.8	1.45486	.97577	1.35807
51.6	1.40993	.92958	1.33269	51.6	1.44197	.95945	1.34725
51.4	1.39798	.91455	1.32232	51.4	1.42926	.94348	1.33655
51.2	1.38619	.89983	1.31206	51.2	1.41674	.92784	1.32597
51.0	1.37454	.88540	1.30191	51.0	1.40439	.91252	1.31552
50.8	1.36304	.87125	1.29186	50.8	1.39220	.89752	1.30519
50.6	1.35168	.85737	1.28192	50.6	1.38018	.88284	1.29497

$\gamma = 0.08$				$\gamma = 0.09$			
φ	X	Y	T	φ	X	Y	T
60°.0	2.44854	2.47491	2.03488	59°.0	2.43774	2.40308	1.98477
59.8	2.40421	2.39843	2.01008	58.8	2.38974	2.32351	1.95971
59.6	2.36247	2.32699	1.98615	58.6	2.34500	2.24992	1.93565
59.4	2.32298	2.25995	1.96302	58.4	2.30304	2.18144	1.91249
59.2	2.28550	2.19682	1.94061	58.2	2.26349	2.11740	1.89013
59.0	2.24980	2.13716	1.91887	58.0	2.22605	2.05726	1.86850
58.8	2.21570	2.08063	1.89775	57.8	2.19049	2.00056	1.84753
58.6	2.18304	2.02693	1.87720	57.6	2.15659	1.94694	1.82718
58.4	2.15171	1.97579	1.85719	57.4	2.12420	1.89609	1.80738
58.2	2.12158	1.92700	1.83767	57.2	2.09316	1.84775	1.78812
58.0	2.09255	1.88037	1.81862	57.0	2.06336	1.80168	1.76934
57.8	2.06455	1.83573	1.80002	56.8	2.03470	1.75770	1.75102
57.6	2.03749	1.79292	1.78183	56.6	2.00707	1.71564	1.73314
57.4	2.01131	1.75182	1.76404	56.4	1.98040	1.67535	1.71566
57.2	1.98594	1.71231	1.74662	56.2	1.95462	1.63670	1.69856
57.0	1.96134	1.67428	1.72956	56.0	1.92967	1.59956	1.68182
56.8	1.93745	1.63764	1.71284	55.8	1.90548	1.56384	1.66544
56.6	1.91424	1.60230	1.69644	55.6	1.88202	1.52944	1.64938
56.4	1.89166	1.56818	1.68036	55.4	1.85923	1.49628	1.63363
56.2	1.86968	1.53522	1.66457	55.2	1.83707	1.46428	1.61818
56.0	1.84826	1.50334	1.64906	55.0	1.81551	1.43338	1.60302
55.8	1.82737	1.47249	1.63383	54.8	1.79451	1.40350	1.58813
55.6	1.80699	1.44261	1.61887	54.6	1.77405	1.37460	1.57350
55.4	1.78709	1.41366	1.60415	54.4	1.75409	1.34661	1.55913
55.2	1.76765	1.38559	1.58968	54.2	1.73461	1.31950	1.54500
55.0	1.74864	1.35834	1.57545	54.0	1.71558	1.29321	1.53110
54.8	1.73006	1.33189	1.56144	53.8	1.69698	1.26771	1.51742
54.6	1.71187	1.30620	1.54765	53.6	1.67880	1.24295	1.50397
54.4	1.69406	1.28123	1.53407	53.4	1.66101	1.21891	1.49072
54.2	1.67661	1.25695	1.52069	53.2	1.64359	1.19554	1.47767
54.0	1.65951	1.23333	1.50752	53.0	1.62653	1.17283	1.46482
53.8	1.64275	1.21034	1.49454	52.8	1.60982	1.15073	1.45216
53.6	1.62630	1.18796	1.48174	52.6	1.59344	1.12922	1.43968
53.4	1.61017	1.16615	1.46912	52.4	1.57737	1.10828	1.42738
53.2	1.59433	1.14491	1.45668	52.2	1.56161	1.08789	1.41525
53.0	1.57878	1.12419	1.44441	52.0	1.54614	1.06802	1.40328
52.8	1.56351	1.10399	1.43230	51.8	1.53095	1.04865	1.39147
52.6	1.54850	1.08429	1.42036	51.6	1.51603	1.02976	1.37982
52.4	1.53375	1.06507	1.40858	51.4	1.50137	1.01133	1.36834
52.2	1.51924	1.04630	1.39694	51.2	1.48696	.99335	1.35700
52.0	1.50497	1.02797	1.38545	51.0	1.47280	.97579	1.34581
51.8	1.49094	1.01007	1.37410	50.8	1.45887	.95865	1.33476
51.6	1.47713	.99258	1.36290	50.6	1.44517	.94191	1.32385
51.4	1.46354	.97549	1.35183	50.4	1.43169	.92556	1.31307
51.2	1.45015	.95878	1.34090	50.2	1.41842	.90957	1.30241
51.0	1.43696	.94244	1.33010	50.0	1.40535	.89393	1.29186
50.8	1.42397	.92646	1.31943	49.8	1.39248	.87865	1.28144
50.6	1.41118	.91083	1.30888	49.6	1.37980	.86370	1.27115

$\gamma = 0.10$				$\gamma = 0.11$			
φ	X	Y	T	φ	X	Y	T
58°.0	2.42326	2.32865	1.93480	57°.0	2.40402	2.25049	1.88501
57.8	2.37144	2.24604	1.90959	56.8	2.34841	2.16518	1.85950
57.6	2.32368	2.17049	1.88543	56.6	2.29779	2.08810	1.83528
57.4	2.27931	2.10084	1.86226	56.4	2.25119	2.01771	1.81218
57.2	2.23780	2.03618	1.83998	56.2	2.20795	1.95286	1.79004
57.0	2.19876	1.97583	1.81849	56.0	2.16753	1.89271	1.76874
56.8	2.16188	1.91925	1.79772	55.8	2.12955	1.83660	1.74820
56.6	2.12689	1.86598	1.77759	55.6	2.09367	1.78402	1.72835
56.4	2.09358	1.81566	1.75805	55.4	2.05966	1.73453	1.70911
56.2	2.06179	1.76799	1.73906	55.2	2.02730	1.68779	1.69044
56.0	2.03136	1.72270	1.72059	55.0	1.99642	1.64352	1.67229
55.8	2.00217	1.67958	1.70258	54.8	1.96687	1.60147	1.65463
55.6	1.97411	1.63844	1.68502	54.6	1.93852	1.56144	1.63742
55.4	1.94708	1.59911	1.66787	54.4	1.91128	1.52324	1.62062
55.2	1.92100	1.56146	1.65111	54.2	1.88504	1.48673	1.60422
55.0	1.89581	1.52534	1.63472	54.0	1.85974	1.45177	1.58819
54.8	1.87143	1.49066	1.61868	53.8	1.83529	1.41824	1.57252
54.6	1.84782	1.45730	1.60297	53.6	1.81163	1.38603	1.55717
54.4	1.82491	1.42519	1.58757	53.4	1.78872	1.35506	1.54213
54.2	1.80268	1.39424	1.57247	53.2	1.76649	1.32525	1.52739
54.0	1.78106	1.36438	1.55766	53.0	1.74491	1.29650	1.51294
53.8	1.76003	1.33555	1.54312	52.8	1.72394	1.26877	1.49875
53.6	1.73956	1.30768	1.52884	52.6	1.70353	1.24199	1.48482
53.4	1.71961	1.28071	1.51481	52.4	1.68367	1.21609	1.47114
53.2	1.70015	1.25461	1.50102	52.2	1.66431	1.19104	1.45770
53.0	1.68116	1.22932	1.48746	52.0	1.64542	1.16679	1.44448
52.8	1.66262	1.20480	1.47412	51.8	1.62699	1.14328	1.43149
52.6	1.64450	1.18101	1.46100	51.6	1.60900	1.12050	1.41870
52.4	1.62678	1.15792	1.44808	51.4	1.59141	1.09839	1.40611
52.2	1.60945	1.13550	1.43536	51.2	1.57422	1.07692	1.39372
52.0	1.59249	1.11371	1.42283	51.0	1.55739	1.05607	1.38151
51.8	1.57587	1.09252	1.41049	50.8	1.54092	1.03580	1.36949
51.6	1.55959	1.07191	1.39832	50.6	1.52479	1.01610	1.35765
51.4	1.54363	1.05185	1.38633	50.4	1.50898	.99692	1.34597
51.2	1.52798	1.03232	1.37451	50.2	1.49349	.97826	1.33445
51.0	1.51262	1.01330	1.36286	50.0	1.47829	.96008	1.32310
50.8	1.49755	.99476	1.35136	49.8	1.46338	.94238	1.31190
50.6	1.48276	.97669	1.34001	49.6	1.44875	.92512	1.30085
50.4	1.46823	.95906	1.32881	49.4	1.43438	.90829	1.28994
50.2	1.45396	.94186	1.31776	49.2	1.42026	.89188	1.27917
50.0	1.43993	.92508	1.30685	49.0	1.40639	.87587	1.26855
49.8	1.42613	.90870	1.29608	48.8	1.39275	.86024	1.25806
49.6	1.41256	.89270	1.28544	48.6	1.37934	.84498	1.24770
49.4	1.39921	.87707	1.27493	48.4	1.36616	.83007	1.23746
49.2	1.38607	.86180	1.26454	48.2	1.35319	.81551	1.22734
49.0	1.37315	.84687	1.25428	48.0	1.34042	.80128	1.21734
48.8	1.36042	.83227	1.24414	47.8	1.32785	.78737	1.20746
48.6	1.34788	.81800	1.23412	47.6	1.31547	.77377	1.19769

γ = 0.12				γ = 0.13			
φ	X	Y	T	φ	X	Y	T
56.0	2.37888	2.16734	1.83487	55.0	2.34664	2.07817	1.78424
55.8	2.31979	2.08005	1.80925	54.8	2.28474	1.99009	1.75868
55.6	2.26665	2.00215	1.78508	54.6	2.22971	1.91236	1.73470
55.4	2.21820	1.93166	1.76213	54.4	2.17996	1.84260	1.71201
55.2	2.17357	1.86719	1.74020	54.2	2.13441	1.77922	1.69040
55.0	2.13210	1.80775	1.71917	54.0	2.09231	1.72105	1.66973
54.8	2.09331	1.75256	1.69894	53.8	2.05309	1.66727	1.64987
54.6	2.05683	1.70103	1.67941	53.6	2.01633	1.61722	1.63074
54.4	2.02237	1.65271	1.66052	53.4	1.98169	1.57041	1.61225
54.2	1.98967	1.60720	1.64221	53.2	1.94891	1.52643	1.59435
54.0	1.95854	1.56419	1.62444	53.0	1.91777	1.48495	1.57699
53.8	1.92882	1.52344	1.60715	52.8	1.88809	1.44571	1.56011
53.6	1.90037	1.48471	1.59032	52.6	1.85972	1.40846	1.54369
53.4	1.87307	1.44781	1.57390	52.4	1.83253	1.37303	1.52769
53.2	1.84682	1.41260	1.55789	52.2	1.80642	1.33925	1.51208
53.0	1.82153	1.37892	1.54224	52.0	1.78130	1.30698	1.49683
52.8	1.79714	1.34666	1.52694	51.8	1.75708	1.27609	1.48193
52.6	1.77356	1.31570	1.51197	51.6	1.73370	1.24648	1.46735
52.4	1.75074	1.28596	1.49731	51.4	1.71108	1.21805	1.45308
52.2	1.72862	1.25735	1.48294	51.2	1.68918	1.19071	1.43909
52.0	1.70717	1.22979	1.46886	51.0	1.66795	1.16439	1.42538
51.8	1.68634	1.20322	1.45504	50.8	1.64734	1.13903	1.41194
51.6	1.66608	1.17757	1.44147	50.6	1.62731	1.11457	1.39874
51.4	1.64637	1.15279	1.42814	50.4	1.60783	1.09094	1.38577
51.2	1.62717	1.12883	1.41505	50.2	1.58887	1.06810	1.37304
51.0	1.60846	1.10564	1.40218	50.0	1.57040	1.04600	1.36052
50.8	1.59021	1.08318	1.38953	49.8	1.55238	1.02460	1.34821
50.6	1.57239	1.06142	1.37707	49.6	1.53480	1.00387	1.33609
50.4	1.55499	1.04030	1.36482	49.4	1.51763	.98377	1.32417
50.2	1.53798	1.01981	1.35276	49.2	1.50085	.96426	1.31244
50.0	1.52134	.99992	1.34088	49.0	1.48445	.94533	1.30088
49.8	1.50506	.98058	1.32917	48.8	1.46840	.92693	1.28950
49.6	1.48912	.96179	1.31764	48.6	1.45269	.90905	1.27828
49.4	1.47351	.94351	1.30627	48.4	1.43731	.89166	1.26722
49.2	1.45820	.92571	1.29507	48.2	1.42223	.87473	1.25631
49.0	1.44320	.90839	1.28401	48.0	1.40745	.85826	1.24556
48.8	1.42848	.89152	1.27310	47.8	1.39295	.84222	1.23495
48.6	1.41403	.87508	1.26234	47.6	1.37873	.82659	1.22448
48.4	1.39985	.85905	1.25172	47.4	1.36477	.81136	1.21415
48.2	1.38593	.84342	1.24124	47.2	1.35106	.79650	1.20395
48.0	1.37225	.82817	1.23090	47.0	1.33759	.78200	1.19387
47.8	1.35880	.81329	1.22069	46.8	1.32435	.76785	1.18392
47.6	1.34558	.79876	1.21060	46.6	1.31134	.75404	1.17409
47.4	1.33258	.78457	1.20063	46.4	1.29855	.74056	1.16438
47.2	1.31979	.77071	1.19077	46.2	1.28597	.72739	1.15478
47.0	1.30720	.75716	1.18103	46.0	1.27358	.71452	1.14530
46.8	1.29481	.74392	1.17140	45.8	1.26139	.70194	1.13593
[illegible]	1.28261	.73097	1.16188	45.6	1.24939	.68964	1.12666

γ = 0.14				γ = 0.15			
φ	X	Y	T	φ	X	Y	T
54.0°	2.30632	1.98239	1.73297	53.0°	2.25742	1.88017	1.68106
53.8	2.24268	1.89511	1.70768	52.8	2.19343	1.79555	1.65629
53.6	2.18662	1.81878	1.68405	52.6	2.13738	1.72197	1.63321
53.4	2.13627	1.75073	1.66177	52.4	2.09724	1.65662	1.61148
53.2	2.09040	1.68919	1.64059	52.2	2.04169	1.59768	1.59086
53.0	2.04816	1.63293	1.62037	52.0	1.99983	1.54391	1.57118
52.8	2.00893	1.58106	1.60097	51.8	1.96103	1.49442	1.55232
52.6	1.97224	1.53290	1.58230	51.6	1.92480	1.44854	1.53417
52.4	1.93775	1.48795	1.56427	51.4	1.89076	1.40575	1.51667
52.2	1.90516	1.44578	1.54683	51.2	1.85864	1.36565	1.49973
52.0	1.87425	1.40607	1.52992	51.0	1.82819	1.32791	1.48331
51.8	1.84482	1.36853	1.51350	50.8	1.79922	1.29226	1.46737
51.6	1.81672	1.33295	1.49752	50.6	1.77157	1.25849	1.45186
51.4	1.78982	1.29913	1.48195	50.4	1.74512	1.22640	1.43675
51.2	1.76400	1.26691	1.46677	50.2	1.71975	1.19584	1.42202
51.0	1.73918	1.23615	1.45195	50.0	1.69536	1.16667	1.40764
50.8	1.71527	1.20672	1.43746	49.8	1.67187	1.13877	1.39358
50.6	1.69219	1.17852	1.42329	49.6	1.64921	1.11205	1.37983
50.4	1.66988	1.15146	1.40941	49.4	1.62731	1.08641	1.36636
50.2	1.64829	1.12545	1.39582	49.2	1.60612	1.06177	1.35317
50.0	1.62737	1.10043	1.38250	49.0	1.58558	1.03806	1.34024
49.8	1.60706	1.07632	1.36943	48.8	1.56566	1.01522	1.32756
49.6	1.58734	1.05306	1.35660	48.6	1.54631	.99320	1.31511
49.4	1.56816	1.03060	1.34400	48.4	1.52750	.97194	1.30288
49.2	1.54950	1.00890	1.33163	48.2	1.50919	.95139	1.29086
49.0	1.53132	.98792	1.31946	48.0	1.49136	.93151	1.27905
48.8	1.51359	.96760	1.30749	47.8	1.47397	.91228	1.26743
48.6	1.49630	.94791	1.29572	47.6	1.45702	.89364	1.25599
48.4	1.47941	.92883	1.28414	47.4	1.44046	.87557	1.24474
48.2	1.46292	.91031	1.27273	47.2	1.42428	.85804	1.23366
48.0	1.44679	.89233	1.26149	47.0	1.40847	.84102	1.22275
47.8	1.43101	.87487	1.25042	46.8	1.39300	.82449	1.21199.
47.6	1.41557	.85790	1.23952	46.6	1.37786	.80843	1.20139
47.4	1.40045	.84140	1.22876	46.4	1.36303	.79280	1.19094
47.2	1.38563	.82534	1.21816	46.2	1.34851	.77760	1.18064
47.0	1.37111	.80971	1.20770	46.0	1.33427	.76281	1.17047
46.8	1.35688	.79449	1.19738	45.8	1.32030	.74839	1.16044
46.6	1.34292	.77966	1.18719	45.6	1.30660	.73435	1.15053
46.4	1.32920	.76520	1.17713	45.4	1.29315	.72067	1.14076
46.2	1.31572	.75110	1.16720	45.2	1.27995	.70732	1.13110
46.0	1.30247	.73736	1.15741	45.0	1.26697	.69430	1.12157
45.8	1.28945	.72394	1.14774	44.8	1.25421	.68159	1.11216
45.6	1.27666	.71084	1.13818	44.6	1.24167	.66918	1.10286
45.4	1.26409	.69805	1.12873	44.4	1.22935	.65707	1.09366
45.2	1.25173	.68556	1.11939	44.2	1.21723	.64524	1.08457
45.0	1.23959	.67336	1.11015	44.0	1.20531	.63368	1.07558
44.8	1.22765	.66143	1.10102	43.8	1.19358	.62238	1.06669
44.6	1.21588	.64976	1.09200	43.6	1.18203	.61133	1.05790

γ = 0.16				γ = 0.17			
φ	X	Y	T	φ	X	Y	T
52.0°	2.20019	1.77260	1.62859	51.0°	2.13564	1.66158	1.57577
51.8	2.13736	1.69247	1.60460	50.8	2.07535	1.58739	1.55277
51.6	2.08241	1.62287	1.58225	50.6	2.02246	1.52276	1.53132
51.4	2.03328	1.56111	1.56122	50.4	1.97508	1.46529	1.51111
51.2	1.98869	1.50545	1.54127	50.2	1.93201	1.41340	1.49191
51.0	1.94773	1.45469	1.52223	50.0	1.89240	1.36603	1.47358
50.8	1.90978	1.40798	1.50398	49.8	1.85566	1.32239	1.45600
50.6	1.87434	1.36468	1.48642	49.6	1.82133	1.28191	1.43908
50.4	1.84107	1.32431	1.46947	49.4	1.78907	1.24414	1.42274
50.2	1.80966	1.28648	1.45308	49.2	1.75860	1.20872	1.40692
50.0	1.77989	1.25088	1.43719	49.0	1.72971	1.17536	1.39159
49.8	1.75158	1.21725	1.42176	48.8	1.70222	1.14385	1.37668
49.6	1.72456	1.18539	1.40674	48.6	1.67597	1.11397	1.36218
49.4	1.69871	1.15512	1.39211	48.4	1.65085	1.08557	1.34805
49.2	1.67391	1.12629	1.37785	48.2	1.62674	1.05852	1.33426
49.0	1.65007	1.09878	1.36392	48.0	1.60356	1.03268	1.32079
48.8	1.62712	1.07246	1.35030	47.8	1.58123	1.00797	1.30762
48.6	1.60497	1.04725	1.33698	47.6	1.55968	.98428	1.29473
48.4	1.58356	1.02305	1.32393	47.4	1.53885	.96155	1.28211
48.2	1.56285	.99981	1.31115	47.2	1.51868	.93970	1.26974
48.0	1.54278	.97743	1.29862	47.0	1.49914	.91866	1.25760
47.8	1.52331	.95588	1.28632	46.8	1.48017	.89840	1.24570
47.6	1.50439	.93510	1.27424	46.6	1.46175	.87884	1.23400
47.4	1.48600	.91503	1.26238	46.4	1.44383	.85996	1.22251
47.2	1.46810	.89563	1.25073	46.2	1.42639	.84171	1.21122
47.0	1.45067	.87687	1.23927	46.0	1.40939	.82405	1.20011
46.8	1.43367	.85871	1.22800	45.8	1.39282	.80695	1.18918
46.6	1.41709	.84111	1.21690	45.6	1.37665	.79038	1.17843
46.4	1.40090	.82405	1.20598	45.4	1.36086	.77431	1.16783
46.2	1.38508	.80749	1.19523	45.2	1.34543	.75872	1.15740
46.0	1.36962	.79142	1.18463	45.0	1.33034	.74358	1.14712
45.8	1.35449	.77581	1.17419	44.8	1.31558	.72887	1.13698
45.6	1.33968	.76064	1.16389	44.6	1.30113	.71457	1.12699
45.4	1.32518	.74588	1.15374	44.4	1.28698	.70066	1.11714
45.2	1.31097	.73152	1.14373	44.2	1.27311	.68712	1.10741
45.0	1.29703	.71754	1.13385	44.0	1.25950	.67394	1.09782
44.8	1.28335	.70392	1.12410	43.8	1.24616	.66110	1.08835
44.6	1.26993	.69065	1.11447	43.6	1.23307	.64858	1.07900
44.4	1.25677	.67772	1.10497	43.4	1.22021	.63638	1.06976
44.2	1.24386	.66511	1.09559	43.2	1.20758	.62449	1.06064
44.0	1.23118	.65280	1.08632	43.0	1.19518	.61288	1.05163
43.8	1.21872	.64079	1.07716	42.8	1.18299	.60155	1.04272
43.6	1.20646	.62907	1.06811	42.6	1.17100	.59048	1.03392
43.4	1.19439	.61763	1.05916	42.4	1.15920	.57968	1.02522
43.2	1.18251	.60644	1.05031	42.2	1.14760	.56912	1.01661
43.0	1.17082	.59551	1.04157	42.0	1.13618	.55880	1.00811
42.8	1.15931	.58485	1.03292	41.8	1.12494	.54872	.99969
42.6	1.14708	57439	1.02437	41.6	1.11387	.53885	.99136

γ = 0.18				γ = 0.19			
φ	X	Y	T	φ	X	Y	T
50.0°	2.06533	1.54956	1.52292	49.0°	1.99111	1.43884	1.47035
49.8	2.00860	1.48218	1.50107	48.8	1.93855	1.37858	1.44975
49.6	1.95852	1.42312	1.48063	48.6	1.89175	1.32530	1.43038
49.4	1.91346	1.37036	1.46132	48.4	1.84937	1.27740	1.41203
49.2	1.87235	1.32256	1.44295	48.2	1.81053	1.23380	1.39452
49.0	1.83445	1.27881	1.42538	48.0	1.77459	1.19374	1.37775
48.8	1.79921	1.23841	1.40851	47.8	1.74107	1.15665	1.36162
48.6	1.76624	1.20087	1.39226	47.6	1.70963	1.12209	1.34605
48.4	1.73520	1.16579	1.37655	47.4	1.67997	1.08972	1.33099
48.2	1.70586	1.13285	1.36134	47.2	1.65187	1.05928	1.31639
48.0	1.67800	1.10181	1.34657	47.0	1.62516	1.03053	1.30220
47.8	1.65146	1.07244	1.33221	46.8	1.59969	1.00330	1.28840
47.6	1.62611	1.04457	1.31824	46.6	1.57531	.97744	1.27495
47.4	1.60182	1.01806	1.30461	46.4	1.55194	.95281	1.26183
47.2	1.57850	.99279	1.29130	46.2	1.52948	.92931	1.24902
47.0	1.55606	.96864	1.27830	46.0	1.50785	.90683	1.23648
46.8	1.53443	.94553	1.26559	45.8	1.48698	.88529	1.22422
46.6	1.51355	.92337	1.25314	45.6	1.46682	.86463	1.21221
46.4	1.49335	.90209	1.24094	45.4	1.44730	.84477	1.20043
46.2	1.47379	.88162	1.22898	45.2	1.42839	.82566	1.18888
46.0	1.45483	.86191	1.21724	45.0	1.41005	.80725	1.17754
45.8	1.43642	.84291	1.20572	44.8	1.39223	.78949	1.16641
45.6	1.41852	.82457	1.19441	44.6	1.37490	.77235	1.15547
45.4	1.40112	.80686	1.18329	44.4	1.35804	.75577	1.14471
45.2	1.38417	.78973	1.17235	44.2	1.34161	.73974	1.13413
45.0	1.36765	.77315	1.16160	44.0	1.32559	.72422	1.12372
44.8	1.35153	.75710	1.15101	43.8	1.30996	.70918	1.11347
44.6	1.33581	.74153	1.14058	43.6	1.29470	.69459	1.10337
44.4	1.32044	.72644	1.13032	43.4	1.27978	.68044	1.09342
44.2	1.30543	.71178	1.12020	43.2	1.26520	.66670	1.08362
44.0	1.29074	.69755	1.11023	43.0	1.25093	.65335	1.07396
43.8	1.27637	.68372	1.10040	42.8	1.23697	.64037	1.06442
43.6	1.26230	.67027	1.09071	42.6	1.22328	.62774	1.05502
43.4	1.24851	.65718	1.08114	42.4	1.20988	.61546	1.04574
43.2	1.23499	.64445	1.07170	42.2	1.19673	.60350	1.03658
43.0	1.22173	.63204	1.06239	42.0	1.18384	.59185	1.02754
42.8	1.20872	.61994	1.05320	41.8	1.17118	.58049	1.01861
42.6	1.19595	.60815	1.04412	41.6	1.15875	.56942	1.00979
42.4	1.18342	.59666	1.03515	41.4	1.14655	.55862	1.00107
42.2	1.17111	.58547	1.02628	41.2	1.13456	.54808	.99246
42.0	1.15901	.57455	1.01751	41.0	1.12277	.53780	.98395
41.8	1.14711	.56388	1.00885	40.8	1.11118	.52776	.97554
41.6	1.13541	.55346	1.00029	40.6	1.09978	.51796	.96722
41.4	1.12390	.54328	.99183	40.4	1.08856	.50838	.95899
41.2	1.11258	.53333	.98346	40.2	1.07752	.49901	.95085
41.0	1.10143	.52360	.97518	40.0	1.06665	.48986	.94279
40.8	1.09045	.51409	.96699	39.8	1.05595	.48091	.93482
40.6	1.07964	.50479	.95889	39.6	1.04541	.47215	.92693

$\gamma = 0.20$				$\gamma = 0.3$			
φ	X	Y	T	φ	X	Y	T
48°.0	1.91475	1.33144	1.41840	40°.0	1.47905	.776117	1.08479
47.8	1.86658	1.27812	1.39905	39.8	1.44479	.747469	1.07054
47.6	1.82326	1.23051	1.38078	39.6	1.41331	.721330	1.05691
47.4	1.78375	1.18740	1.36340	39.4	1.38411	.697262	1.04383
47.2	1.74734	1.14794	1.34678	39.2	1.35684	.674936	1.03122
47.0	1.71350	1.11151	1.33081	39.0	1.33120	.654103	1.01903
46.8	1.68182	1.07766	1.31542	38.8	1.30699	.634565	1.00722
46.6	1.65202	1.04603	1.30055	38.6	1.28402	.616164	.99574
46.4	1.62383	1.01633	1.28614	38.4	1.26216	.598772	.98458
46.2	1.59708	.988332	1.27215	38.2	1.24127	.582280	.97370
46.0	1.57159	.961847	1.25855	38.0	1.22128	.566599	.96308
45.8	1.54724	.936718	1.24530	37.8	1.20208	.551653	.95271
45.6	1.52391	.912812	1.23238	37.6	1.18361	.537377	.94256
45.4	1.50151	.890016	1.21977	37.4	1.16580	.523714	.93262
45.2	1.47995	.868234	1.20743	37.2	1.14861	.510615	.92289
45.0	1.45917	.847381	1.19537	37.0	1.13198	.498037	.91333
44.8	1.43911	.827384	1.18355	36.8	1.11587	.485942	.90396
44.6	1.41970	.808178	1.17197	36.6	1.10025	.474297	.89475
44.4	1.40090	.789706	1.16062	36.4	1.08507	.463071	.88569
44.2	1.38267	.771917	1.14947	36.2	1.07033	.452236	.87679
44.0	1.36498	.754766	1.13853	36.0	1.05597	.441769	.86803
43.8	1.34777	.738212	1.12777	35.8	1.04199	.431647	.85940
43.6	1.33104	.722218	1.11720	35.6	1.02836	.421851	.85091
43.4	1.31474	.706751	1.10680	35.4	1.01506	.412363	.84254
43.2	1.29885	.691780	1.09657	35.2	1.00207	.403166	.83429
43.0	1.28336	.676277	1.08650	35.0	.98937	.394244	.82615
42.8	1.26823	.663218	1.07658	34.8	.97696	.385584	.81813
42.6	1.25345	.649579	1.06680	34.6	.96481	.377172	.81021
42.4	1.23900	.636339	1.05717	34.4	.95291	.368996	.80239
42.2	1.22486	.623479	1.04767	34.2	.94126	.361046	.79467
42.0	1.21103	.610979	1.03830	34.0	.92984	.353312	.78704
41.8	1.19748	.598823	1.02906	33.8	.91863	.345784	.77951
41.6	1.18420	.586996	1.01995	33.6	.90764	.338453	.77206
41.4	1.17119	.575483	1.01095	33.4	.89685	.331311	.76470
41.2	1.15843	.564270	1.00206	33.2	.88625	.324350	.75743
41.0	1.14590	.553344	.99328	33.0	.87584	.317563	.75023
40.8	1.13361	.542692	.98462	32.8	.86561	.310942	.74311
40.6	1.12153	.532304	.97605	32.6	.85555	.304481	.73607
40.4	1.10966	.522170	.96759	32.4	.84565	.298174	.72910
40.2	1.09800	.512280	.95922	32.2	.83591	.292015	.72220
40.0	1.08653	.502625	.95095	32.0	.82632	.286000	.71537
39.8	1.07526	.493196	.94278	31.8	.81688	.280124	.70861
39.6	1.06416	.483984	.93469	31.6	.80758	.274381	.70191
39.4	1.05324	.474982	.92668	31.4	.79842	.268767	.69528
39.2	1.04249	.466182	.91877	31.2	.78939	.263277	.68871
39.0	1.03190	.457578	.91093	31.0	.78049	.257908	.68220
38.8	1.02147	.449162	.90318	30.8	.77171	.252656	.67575
38.6	1.01119	.440928	.89551	30.6	.76305	.247516	.66936

$\gamma = 0.4$				$\gamma = 0.5$			
φ	X	Y	T	φ	X	Y	T
34.2°	1.24777	.536087	.89410	29.6°	1.06591	.384666	.75459
34.0	1.21572	.514384	.88133	29.4	1.03607	.367783	.74287
33.8	1.18649	.494743	.86916	29.2	1.00900	.352587	.73172
33.6	1.15954	.476774	.85750	29.0	.98413	.338743	.72106
33.4	1.13449	.460188	.84629	28.8	.96107	.326013	.71081
33.2	1.11103	.444779	.83546	28.6	.93953	.314219	.70093
33.0	1.08894	.430379	.82498	28.4	.91928	.303226	.69136
32.8	1.06805	.416859	.81481	28.2	.90015	.292927	.68208
32.6	1.04819	.404114	.80492	28.0	.88201	.283238	.67306
32.4	1.02927	.392057	.79528	27.8	.86473	.274088	.66427
32.2	1.01117	.380618	.78588	27.6	.84822	.265421	.65570
32.0	.99383	.369734	.77669	27.4	.83240	.257188	.64732
31.8	.97715	.359357	.76770	27.2	.81722	.249348	.63913
31.6	.96110	.349440	.75891	27.0	.80260	.241866	.63110
31.4	.94561	.339947	.75028	26.8	.78850	.234713	.62323
31.2	.93063	.330844	.74182	26.6	.77488	.227862	.61552
31.0	.91614	.322101	.73351	26.4	.76170	.221289	.60794
30.8	.90209	.313693	.72535	26.2	.74892	.214976	.60049
30.6	.88846	.305596	.71733	26.0	.73653	.208903	.59316
30.4	.87521	.297791	.70944	25.8	.72448	.203055	.58595
30.2	.86232	.290258	.70167	25.6	.71277	.197418	.57886
30.0	.84976	.282981	.69402	25.4	.70136	.191977	.57187
29.8	.83753	.275945	.68648	25.2	.69025	.186722	.56498
29.6	.82559	.269136	.67905	25.0	.67940	.181643	.55818
29.4	.81393	.262542	.67172	24.8	.66882	.176728	.55148
29.2	.80255	.256152	.66449	24.6	.65847	.171970	.54487
29.0	.79141	.249954	.65735	24.4	.64836	.167361	.53834
28.8	.78052	.243939	.65031	24.2	.63846	.162892	.53189
28.6	.76985	.238098	.64335	24.0	.62877	.158557	.52552
28.4	.75940	.232424	.63648	23.8	.61928	.154350	.51922
28.2	.74916	.226908	.62969	23.6	.60997	.150265	.51300
28.0	.73911	.221543	.62298	23.4	.60084	.146297	.50684
27.8	.72925	.216323	.61634	23.2	.59189	.142440	.50075
27.6	.71957	.211242	.60977	23.0	.58309	.138689	.49473
27.4	.71007	.206294	.60328	22.8	.57446	.135040	.48877
27.2	.70073	.201473	.59686	22.6	.56597	.131490	.48287
27.0	.69155	.196775	.59050	22.4	.55763	.128034	.47703
26.8	.68252	.192195	.58420	22.2	.54942	.124668	.47124
26.6	.67364	.187728	.57797	22.0	.54135	.121390	.46551
26.4	.66489	.183370	.57180	21.8	.53341	.118196	.45983
26.2	.65629	.179117	.56568	21.6	.52559	.115083	.45420
26.0	.64781	.174966	.55963	21.4	.51788	.112048	.44862
25.8	.63946	.170913	.55363	21.2	.51028	.109088	.44310
25.6	.63124	.166954	.54768	21.0	.50280	.106200	.43763
25.4	.62313	.163086	.54178	20.8	.49542	.103384	.43220
25.2	.61514	.159307	.53594	20.6	.48815	.100636	.42682
25.0	.60726	.155615	.53015	20.4	.48097	.097954	.42148
24.8	.59948	.152005	.52440	20.2	.47389	.095336	.41618

γ = 0.6				γ = 0.7			
φ	X	Y	T	φ	X	Y	T
26°.0	.93344	.290751	.65330	23°.0	.81319	.220114	.56922
25.8	.90438	.276640	.64211	22.8	.78636	.208780	.55871
25.6	.87825	.264063	.63151	22.6	.76226	.198698	.54877
25.4	.85442	.252696	.62141	22.4	.74029	.189597	.53929
25.2	.83245	.242310	.61172	22.2	.72004	.181290	.53020
25.0	.81202	.232737	.60239	22.0	.70121	.173643	.52145
24.8	.79288	.223854	.59338	21.8	.68358	.166554	.51300
24.6	.77486	.215563	.58465	21.6	.66697	.159945	.50480
24.4	.75780	.207789	.57617	21.4	.65126	.153754	.49684
24.2	.74159	.200470	.56792	21.2	.63632	.147930	.48909
24.0	.72613	.193554	.55987	21.0	.62208	.142434	.48153
23.8	.71134	.187002	.55201	20.8	.60845	.137231	.47415
23.6	.69716	.180776	.54433	20.6	.59539	.132293	.46693
23.4	.68352	.174848	.53681	20.4	.58282	.127596	.45986
23.2	.67039	.169191	.52943	20.2	.57072	.123118	.45293
23.0	.65771	.163783	.52220	20.0	.55903	.118842	.44613
22.8	.64545	.158605	.51510	19.8	.54774	.114752	.43945
22.6	.63358	.153639	.50812	19.6	.53679	.110835	.43289
22.4	.62207	.148871	.50126	19.4	.52618	.107077	.42643
22.2	.61089	.144286	.49451	19.2	.51588	.103468	.42008
22.0	.60003	.139873	.48786	19.0	.50586	.099998	.41382
21.8	.58945	.135622	.48131	18.8	.49611	.096659	.40765
21.6	.57915	.131522	.47486	18.6	.48660	.093443	.40157
21.4	.56910	.127564	.46849	18.4	.47733	.090343	.39557
21.2	.55929	.123741	.46221	18.2	.46829	.087352	.38966
21.0	.54972	.120045	.45602	18.0	.45945	.084464	.38381
20.8	.54035	.116470	.44990	17.8	.45081	.081674	.37804
20.6	.53119	.113009	.44385	17.6	.44236	.078976	.37234
20.4	.52223	.109657	.43788	17.4	.43409	.076368	.36671
20.2	.51345	.106409	.43198	17.2	.42598	.073843	.36113
20.0	.50484	.103259	.42614	17.0	.41804	.071399	.35562
19.8	.49640	.100204	.42037	16.8	.41025	.069031	.35017
19.6	.48812	.097238	.41466	16.6	.40260	.066738	.34478
19.4	.47999	.094360	.40901	16.4	.39509	.064514	.33944
19.2	.47201	.091563	.40342	16.2	.38772	.062358	.33416
19.0	.46416	.088847	.39788	16.0	.38047	.060267	.32892
18.8	.45645	.086206	.39239	15.8	.37335	.058237	.32374
18.6	.44887	.083639	.38696	15.6	.36634	.056268	.31860
18.4	.44141	.081143	.38158	15.4	.35945	.054356	.31351
18.2	.43406	.078715	.37625	15.2	.35266	.052500	.30847
18.0	.42683	.076352	.37096	15.0	.34598	.050697	.30346
17.8	.41971	.074053	.36572	14.8	.33940	.048946	.29850
17.6	.41270	.071815	.36053	14.6	.33292	.047245	.29358
17.4	.40579	.069636	.35538	14.4	.32653	.045592	.28870
17.2	.39897	.067513	.35027	14.2	.32023	.043985	.28386
17.0	.39225	.065444	.34520	14.0	.31401	.042424	.27906
16.8	.38562	.063430	.34017	13.8	.30788	.040907	.27429
16.6	.37908	.061468	.33518	13.6	.30183	.039432	.26956

$\gamma = 0.8$				$\gamma = 0.9$			
φ	X	Y	T	φ	X	Y	T
20°.6	.72328	.173439	.50514	18°.6	.64747	.138865	.45242
20.4	.69753	.163809	.49502	18.4	.62289	.130637	.44265
20.2	.67451	.155295	.48546	18.2	.60098	.123395	.43344
20.0	.65361	.147646	.47637	18.0	.58115	.116911	.42469
19.8	.63440	.140692	.46766	17.8	.56295	.111033	.41631
19.6	.61658	.134310	.45928	17.6	.54609	.105653	.40826
19.4	.59992	.128411	.45119	17.4	.53035	.100690	.40049
19.2	.58426	.122924	.44335	17.2	.51556	.096084	.39297
19.0	.56945	.117797	.43575	17.0	.50159	.091787	.38566
18.8	.55539	.112984	.42834	16.8	.48834	.087761	.37855
18.6	.54200	.108450	.42112	16.6	.47573	.083976	.37162
18.4	.52920	.104167	.41407	16.4	.46367	.080405	.36486
18.2	.51693	.100109	.40718	16.2	.45212	.077027	.35824
18.0	.50514	.096255	.40043	16.0	.44103	.073825	.35177
17.8	.49378	.092587	.39382	15.8	.43035	.070782	.34542
17.6	.48283	.089091	.38733	15.6	.42005	.067886	.33919
17.4	.47224	.085752	.38095	15.4	.41009	.065125	.33307
17.2	.46199	.082559	.37468	15.2	.40045	.062488	.32706
17.0	.45205	.079501	.36852	15.0	.39111	.059967	.32114
16.8	.44240	.076569	.36246	14.8	.38204	.057554	.31532
16.6	.43302	.073754	.35648	14.6	.37323	.055242	.30958
16.4	.42389	.071050	.35060	14.4	.36465	.053024	.30393
16.2	.41499	.068450	.34479	14.2	.35630	.050894	.29836
16.0	.40632	.065947	.33906	14.0	.34815	.048848	.29286
15.8	.39786	.063537	.33341	13.8	.34020	.046881	.28743
15.6	.38960	.061213	.32783	13.6	.33244	.044989	.28208
15.4	.38152	.058972	.32232	13.4	.32485	.043167	.27678
15.2	.37361	.056810	.31688	13.2	.31743	.041412	.27155
15.0	.36587	.054722	.31149	13.0	.31016	.039721	.26638
14.8	.35829	.052705	.30617	12.8	.30305	.038091	.26127
14.6	.35087	.050756	.30091	12.6	.29607	.036518	.25621
14.4	.34358	.048872	.29570	12.4	.28923	.035001	.25120
14.2	.33643	.047050	.29054	12.2	.28251	.033537	.24625
14.0	.32942	.045287	.28544	12.0	.27592	.032124	.24134
13.8	.32252	.043581	.28039	11.8	.26945	.030760	.23648
13.6	.31575	.041929	.27538	11.6	.26308	.029442	.23167
13.4	.30909	.040330	.27042	11.4	.25683	.028170	.22690
13.2	.30254	.038782	.26551	11.2	.25068	.026940	.22218
13.0	.29609	.037282	.26064	11.0	.24462	.025753	.21749
12.8	.28974	.035829	.25581	10.8	.23866	.024606	.21285
12.6	.28349	.034421	.25102	10.6	.23279	.023497	.20825
12.4	.27734	.033057	.24627	10.4	.22701	.022426	.20368
12.2	.27128	.031735	.24156	10.2	.22132	.021391	.19914
12.0	.26531	.030454	.23690	10.0	.21571	.020391	.19464
11.8	.25942	.029213	.23227	9.8	.21018	.019425	.19018
11.6	.25361	.028010	.22767	9.6	.20472	.018492	.18575
11.4	.24788	.026844	.22310	9.4	.19934	.017591	.18135
11.2	.24222	.025713	.21856	9.2	.19403	.016721	.17699

$\gamma = 1.0$				$\gamma = 1.1$			
φ	X	Y	T	φ	X	Y	T
17.0°	.59414	.116140	.41265	15.4°	.51899	.090241	.36756
16.8	.56934	.108606	.40293	15.2	.49780	.084445	.35864
16.6	.54752	.102059	.39382	15.0	.47885	.079331	.35022
16.4	.52792	.096251	.38519	14.8	.46163	.074748	.34219
16.2	.51004	.091024	.37696	14.6	.44578	.070591	.33451
16.0	.49357	.086268	.36907	14.4	.43108	.066788	.32711
15.8	.47824	.081903	.36147	14.2	.41732	.063282	.31996
15.6	.46389	.077869	.35412	14.0	.40438	.060032	.31302
15.4	.45037	.074119	.34699	13.8	.39215	.057004	.30629
15.2	.43758	.070618	.34006	13.6	.38053	.054171	.29974
15.0	.42541	.067336	.33331	13.4	.36945	.051512	.29334
14.8	.41381	.064249	.32672	13.2	.35886	.049008	.28709
14.6	.40271	.061337	.32029	13.0	.34871	.046645	.28098
14.4	.39206	.058582	.31399	12.8	.33895	.044409	.27499
14.2	.38182	.055972	.30782	12.6	.32954	.042291	.26912
14.0	.37195	.053493	.30177	12.4	.32047	.040279	.26336
13.8	.36242	.051134	.29583	12.2	.31169	.038366	.25769
13.6	.35320	.048887	.28999	12.0	.30320	.036544	.25212
13.4	.34427	.046744	.28425	11.8	.29496	.034807	.24664
13.2	.33561	.044696	.27860	11.6	.28695	.033150	.24124
13.0	.32720	.042738	.27303	11.4	.27917	.031567	.23592
12.8	.31902	.040864	.26755	11.2	.27160	.030053	.23068
12.6	.31105	.039069	.26214	11.0	.26422	.028605	.22551
12.4	.30329	.037348	.25681	10.8	.25702	.027219	.22040
12.2	.29571	.035696	.25155	10.6	.24999	.025891	.21536
12.0	.28832	.034111	.24635	10.4	.24313	.024618	.21039
11.8	.28109	.032588	.24122	10.2	.23641	.023398	.20547
11.6	.27403	.031125	.23615	10.0	.22985	.022228	.20060
11.4	.26711	.029718	.23113	9.8	.22341	.021105	.19579
11.2	.26034	.028365	.22618	9.6	.21711	.020028	.19103
11.0	.25371	.027063	.22127	9.4	.21093	.018994	.18632
10.8	.24720	.025811	.21642	9.2	.20487	.018001	.18166
10.6	.24082	.024605	.21162	9.0	.19892	.017049	.17704
10.4	.23456	.023444	.20686	8.8	.19308	.016134	.17247
10.2	.22841	.022326	.20215	8.6	.18734	.015255	.16794
10.0	.22236	.021249	.19749	8.4	.18170	.014412	.16346
9.8	.21642	.020212	.19286	8.2	.17615	.013603	.15901
9.6	.21058	.019213	.18828	8.0	.17069	.012826	.15460
9.4	.20483	.018252	.18374	7.8	.16532	.012080	.15023
9.2	.19918	.017325	.17924	7.6	.16003	.011365	.14589
9.0	.19361	.016433	.17477	7.4	.15482	.010680	.14159
8.8	.18812	.015574	.17034	7.2	.14969	.010022	.13733
8.6	.18271	.014747	.16594	7.0	.14463	.009392	.13309
8.4	.17738	.013951	.16158	6.8	.13965	.008788	.12888
8.2	.17213	.013185	.15726	6.6	.13473	.008210	.12471
8.0	.16696	.012447	.15297	6.4	.12988	.007657	.12057
7.8	.16185	.011738	.14871	6.2	.12509	.007129	.11646
7.6	.15681	.011056	.14448	6.0	.12037	.006625	.11238

$\gamma = 1.2$				$\gamma = 1.3$			
φ	X	Y	T	φ	X	Y	T
14.6°	.52776	.089263	.35707	13.4°	.46665	.071208	.32266
14.4	.49953	.081960	.34683	13.2	.44277	.065561	.31329
14.2	.47586	.075927	.33745	13.0	.42223	.060781	.30459
14.0	.45528	.070755	.32871	12.8	.40407	.056621	.29643
13.8	.43694	.066215	.32047	12.6	.38770	.052932	.28868
13.6	.42031	.062161	.31263	12.4	.37274	.049614	.28128
13.4	.40505	.058497	.30512	12.2	.35892	.046600	.27417
13.2	.39091	.055153	.29790	12.0	.34604	.043839	.26731
13.0	.37770	.052079	.29093	11.8	.33396	.041294	.26068
12.8	.36528	.049236	.28418	11.6	.32258	.038936	.25424
12.6	.35355	.046592	.27762	11.4	.31178	.036740	.24797
12.4	.34242	.044125	.27123	11.2	.30152	.034688	.24187
12.2	.33182	.041813	.26501	11.0	.29172	.032765	.23591
12.0	.32169	.039641	.25892	10.8	.28233	.030958	.23008
11.8	.31198	.037595	.25297	10.6	.27333	.029256	.22438
11.6	.30265	.035663	.24715	10.4	.26466	.027650	.21878
11.4	.29367	.033835	.24143	10.2	.25630	.026131	.21329
11.2	.28500	.032103	.23582	10.0	24823	.024693	.20790
11.0	.27662	.030459	.23031	9.8	.24041	.023329	.20260
10.8	.26851	.028897	.22489	9.6	.23284	.022034	.19738
10.6	.26065	.027411	.21956	9.4	.22549	.020804	.19224
10.4	.25301	.025995	.21431	9.2	.21835	.019635	.18718
10.2	.24559	.024646	.20913	9.0	.21141	.018522	.18220
10.0	.23836	.023359	.20403	8.8	.20464	.017462	.17728
9.8	.23132	.022130	.19900	8.6	.19804	.016453	.17242
9.6	.22446	.020957	.19404	8.4	.19160	.015491	.16763
9.4	.21776	.019836	.18913	8.2	.18532	.014573	.16290
9.2	.21121	.018764	.18429	8.0	.17917	.013699	.15822
9.0	.20481	.017738	.17950	7.8	.17316	.012865	.15359
8.8	.19855	.016758	.17477	7.6	.16728	.012069	.14902
8.6	.19242	.015819	.17009	7.4	.16151	.011310	.14449
8.4	.18641	.014922	.16546	7.2	.15586	.010586	.14002
8.2	.18052	.014062	.16088	7.0	.15032	.009896	.13558
8.0	.17474	.013240	.15635	6.8	.14489	.009238	.13120
7.8	.16908	.012454	.15186	6.6	.13955	.008611	.12685
7.6	.16351	.011701	.14741	6.4	.13430	.008013	.12254
7.4	.15804	.010981	.14300	6.2	.12915	.007444	.11828
7.2	.15267	.010293	.13864	6.0	.12408	.006903	.11405
7.0	.14738	.009634	.13431	5.8	.11910	.006387	.10985
6.8	.14218	.009005	.13002	5.6	.11419	.005898	.10570
6.6	.13706	.008404	.12576	5.4	.10937	.005433	.10157
6.4	.13203	.007830	.12154	5.2	.10461	.004992	.09748
6.2	.12706	.007282	.11735	5.0	.09993	.004574	.09342
6.0	.12218	.006760	.11320	4.8	.09532	.004178	.08939
5.8	.11736	.006262	.10908	4.6	.09077	.003804	.08539
5.6	.11261	.005788	.10499	4.4	.08628	.003451	.08142
5.4	.10793	.005337	.10093	4.2	.08185	.003118	.07748
5.2	.10331	.004908	.09689	4.0	.07748	.002805	.07357

$\gamma = 1.4$				$\gamma = 1.5$			
φ	X	Y	T	φ	X	Y	T
12.2°	.40049	.054244	.28670	11.4°	.37183	.046879	.26693
12.0	.38169	.050213	.27842	11.2	.35357	.043229	.25879
11.8	.36495	.046685	.27061	11.0	.33734	.040046	.25112
11.6	.34979	.043544	.26318	10.8	.32267	.037220	.24384
11.4	.33588	.040714	.25607	10.6	.30923	.034679	.23687
11.2	.32299	.038138	.24923	10.4	.29678	.032373	.23016
11.0	.31095	.035777	.24262	10.2	.28517	.030263	.22369
10.8	.29964	.033599	.23623	10.0	.27427	.028320	.21743
10.6	.28896	.031580	.23001	9.8	.26398	.026524	.21134
10.4	.27882	.029701	.22396	9.6	.25421	.024855	.20542
10.2	.26917	.027946	.21806	9.4	.24492	.023299	.19964
10.0	.25994	.026303	.21230	9.2	.23604	.021845	.19400
9.8	.25110	.024760	.20666	9.0	.22753	.020482	.18848
9.6	.24260	.023307	.20113	8.8	.21936	.019202	.18308
9.4	.23442	.021938	.19572	8.6	.21149	.017998	.17777
9.2	.22653	.020646	.19040	8.4	.20390	.016864	.17257
9.0	.21890	.019424	.18517	8.2	.19657	.015794	.16746
8.8	.21152	.018267	.18003	8.0	.18946	.014783	.16243
8.6	.20435	.017171	.17497	7.8	.18258	.013827	.15748
8.4	.19740	.016131	.16999	7.6	.17590	.012924	.15260
8.2	.19064	.015145	.16508	7.4	.16940	.012068	.14780
8.0	.18405	.014209	.16024	7.2	.16308	.011258	.14306
7.8	.17764	.013319	.15546	7.0	.15692	.010491	.13839
7.6	.17139	.012474	.15075	6.8	.15091	.009764	.13378
7.4	.16529	.011670	.14610	6.6	.14505	.009075	.12922
7.2	.15933	.010906	.14150	6.4	.13932	.008422	.12472
7.0	.15350	.010180	.13695	6.2	.13372	.007803	.12028
6.8	.14779	.009489	.13246	6.0	.12824	.007218	.11588
6.6	.14221	.008833	.12801	5.8	.12288	.006663	.11153
6.4	.13673	.008209	.12361	5.6	.11762	.006139	.10722
6.2	.13137	.007617	.11926	5.4	.11247	.005642	.10296
6.0	.12610	.007054	.11495	5.2	.10741	.005173	.09874
5.8	.12094	.006520	.11068	5.0	.10245	.004731	.09457
5.6	.11586	.006014	.10645	4.8	.09758	.004313	.09043
5.4	.11088	.005534	.10226	4.6	.09279	.003919	.08633
5.2	.10598	.005080	.09810	4.4	.08809	.003549	.08226
5.0	.10116	.004650	.09399	4.2	.08347	.003201	.07823
4.8	.09642	.004244	.08990	4.0	.07891	.002875	.07423
4.6	.09176	.003860	.08585	3.8	.07443	.002569	.07027
4.4	.08716	.003499	.08184	3.6	.07002	.002284	.06634
4.2	.08264	.003158	.07785	3.4	.06568	.002018	.06244
4.0	.07818	.002839	.07390	3.2	.06139	.001771	.05856
3.8	.07379	.002539	.06997	3.0	.05717	.001543	.05472
3.6	.06946	.002259	.06607	2.8	.05301	.001332	.05090
3.4	.06519	.001998	.06220	2.6	.04891	.001138	.04711
3.2	.06098	.001755	.05836	2.4	.04487	.000961	.04335
3.0	.05681	.001530	.05455	2.2	.04088	.000801	.03962
2.8	.05270	.001322	.05076	2.0	.03693	.000657	.03591

$\gamma = 1,6$				$\gamma = 1,7$			
φ	X	Y	T	φ	X	Y	T
10.8°	.35727	.042866	.25411	10.2°	.33774	.038251	.23987
10.6	.33811	.039244	.24577	10.0	.31860	.034841	.23157
10.4	.32135	.036137	.23799	9.8	.30198	.031938	.22384
10.2	.30635	.033411	.23064	9.6	.28718	.029407	.21655
10.0	.29272	.030982	.22363	9.4	.27377	.027162	.20961
9.8	.28018	.028793	.21691	9.2	.26146	.025147	.20297
9.6	.26853	.026803	.21045	9.0	.25006	.023321	.19658
9.4	.25764	.024980	.20419	8.8	.23942	.021653	.19041
9.2	.24740	.023302	.19813	8.6	.22941	.020122	.18444
9.0	.23770	.021749	.19224	8.4	.21996	.018710	.17863
8.8	.22850	.020307	.18650	8.2	.21099	.017401	.17297
8.6	.21972	.018964	.18091	8.0	.20245	.016185	.16746
8.4	.21133	.017709	.17543	7.8	.19429	.015052	.16207
8.2	.20328	.016535	.17008	7.6	.18646	.013994	.15679
8.0	.19554	.015433	.16483	7.4	.17894	.013004	.15163
7.8	.18808	.014398	.15968	7.2	.17170	.012077	.14656
7.6	.18088	.013425	.15462	7.0	.16472	.011206	.14158
7.4	.17392	.012509	.14965	6.8	.15796	.010389	.13669
7.2	.16718	.011645	.14475	6.6	.15142	.009621	.13188
7.0	.16064	.010830	.13994	6.4	.14508	.008898	.12715
6.8	.15428	.010061	.13519	6.2	.13892	.008218	.12248
6.6	.14811	.009336	.13052	6.0	.13294	.007578	.11788
6.4	.14209	.008650	.12590	5.8	.12711	.006976	.11335
6.2	.13623	.008003	.12135	5.6	.12143	.006409	.10887
6.0	.13051	.007392	.11686	5.4	.11590	.005876	.10446
5.8	.12493	.006815	.11242	5.2	.11049	.005374	.10010
5.6	.11947	.006270	.10803	5.0	.10521	.004903	.09579
5.4	.11413	.005756	.10370	4.8	.10004	.004460	.09152
5.2	.10891	.005271	.09941	4.6	.09499	.004044	.08731
5.0	.10380	.004815	.09517	4.4	.09004	.003655	.08314
4.8	.09878	.004385	.09097	4.2	.08519	.003290	.07901
4.6	.09387	.003981	.08681	4.0	.08043	.002949	.07493
4.4	.08904	.003601	.08270	3.8	.07577	.002631	.07088
4.2	.08431	.003245	.07862	3.6	.07119	.002335	.06687
4.0	.07966	.002912	.07458	3.4	.06669	.002060	.06290
3.8	.07509	.002600	.07058	3.2	.06227	.001805	.05897
3.6	.07060	.002310	.06661	3.0	.05793	.001570	.05507
3.4	.06618	.002039	.06267	2.8	.05366	.001354	.05120
3.2	.06183	.001789	.05877	2.6	.04945	.001156	.04737
3.0	.05755	.001557	.05490	2.4	.04532	.000975	.04357
2.8	.05333	.001343	.05106	2.2	.04124	.000811	.03979
2.6	.04918	.001147	.04725	2.0	.03723	.000664	.03605
2.4	.04509	.000969	.04346	1.8	.03327	.000533	.03233
2.2	.04106	.000807	.03971	1.6	.02937	.000417	.02864
2.0	.03708	.000661	.03598	1.4	.02553	.000316	.02497
1.8	.03316	.000530	.03227	1.2	.02174	.000230	.02133
1.6	.02929	.000415	.02859	1.0	.01800	.000159	.01772
1.4	.02547	.000315	.02494	0.8	.01431	.000101	.01413

$\gamma = 1.4$				$\gamma = 1.5$			
φ	X	Y	T	φ	X	Y	T
12.2°	.40049	.054244	.28670	11.4°	.37183	.046879	.26693
12.0	.38169	.050213	.27842	11.2	.35357	.043229	.25879
11.8	.36495	.046685	.27061	11.0	.33734	.040046	.25112
11.6	.34979	.043544	.26318	10.8	.32267	.037220	.24384
11.4	.33588	.040714	.25607	10.6	.30923	.034679	.23687
11.2	.32299	.038138	.24923	10.4	.29678	.032373	.23016
11.0	.31095	.035777	.24262	10.2	.28517	.030263	.22369
10.8	.29964	.033599	.23623	10.0	.27427	.028320	.21743
10.6	.28896	.031580	.23001	9.8	.26398	.026524	.21134
10.4	.27882	.029701	.22396	9.6	.25421	.024855	.20542
10.2	.26917	.027946	.21806	9.4	.24492	.023299	.19964
10.0	.25994	.026303	.21230	9.2	.23604	.021845	.19400
9.8	.25110	.024760	.20666	9.0	.22753	.020482	.18848
9.6	.24260	.023307	.20113	8.8	.21936	.019202	.18308
9.4	.23442	.021938	.19572	8.6	.21149	.017998	.17777
9.2	.22653	.020646	.19040	8.4	.20390	.016864	.17257
9.0	.21890	.019424	.18517	8.2	.19657	.015794	.16746
8.8	.21152	.018267	.18003	8.0	.18946	.014783	.16243
8.6	.20435	.017171	.17497	7.8	.18258	.013827	.15748
8.4	.19740	.016131	.16999	7.6	.17590	.012924	.15260
8.2	.19064	.015145	.16508	7.4	.16940	.012068	.14780
8.0	.18405	.014209	.16024	7.2	.16308	.011258	.14306
7.8	.17764	.013319	.15546	7.0	.15692	.010491	.13839
7.6	.17139	.012474	.15075	6.8	.15091	.009764	.13378
7.4	.16529	.011670	.14610	6.6	.14505	.009075	.12922
7.2	.15933	.010906	.14150	6.4	.13932	.008422	.12472
7.0	.15350	.010180	.13695	6.2	.13372	.007803	.12028
6.8	.14779	.009489	.13246	6.0	.12824	.007218	.11588
6.6	.14221	.008833	.12801	5.8	.12288	.006663	.11153
6.4	.13673	.008209	.12361	5.6	.11762	.006139	.10722
6.2	.13137	.007617	.11926	5.4	.11247	.005642	.10296
6.0	.12610	.007054	.11495	5.2	.10741	.005173	.09874
5.8	.12094	.006520	.11068	5.0	.10245	.004731	.09457
5.6	.11586	.006014	.10645	4.8	.09758	.004313	.09043
5.4	.11088	.005534	.10226	4.6	.09279	.003919	.08633
5.2	.10598	.005080	.09810	4.4	.08809	.003549	.08226
5.0	.10116	.004650	.09399	4.2	.08347	.003201	.07823
4.8	.09642	.004244	.08990	4.0	.07891	.002875	.07423
4.6	.09176	.003860	.08585	3.8	.07443	.002569	.07027
4.4	.08716	.003499	.08184	3.6	.07002	.002284	.06634
4.2	.08264	.003158	.07785	3.4	.06568	.002018	.06244
4.0	.07818	.002839	.07390	3.2	.06139	.001771	.05856
3.8	.07379	.002539	.06997	3.0	.05717	.001543	.05472
3.6	.06946	.002259	.06607	2.8	.05301	.001332	.05090
3.4	.06519	.001998	.06220	2.6	.04891	.001138	.04711
3.2	.06098	.001755	.05836	2.4	.04487	.000961	.04335
3.0	.05681	.001530	.05455	2.2	.04088	.000801	.03962
2.8	.05270	.001322	.05076	2.0	.03693	.000657	.03591

$\gamma = 1.6$				$\gamma = 1.7$			
φ	X	Y	T	φ	X	Y	T
10°.8	.35727	.042866	.25411	10°.2	.33774	.038251	.23987
10.6	.33811	.039244	.24577	10.0	.31860	.034841	.23157
10.4	.32135	.036137	.23799	9.8	.30198	.031938	.22384
10.2	.30635	.033411	.23064	9.6	.28718	.029407	.21655
10.0	.29272	.030982	.22363	9.4	.27377	.027162	.20961
9.8	.28018	.028793	.21691	9.2	.26146	.025147	.20297
9.6	.26853	.026803	.21045	9.0	.25006	.023321	.19658
9.4	.25764	.024980	.20419	8.8	.23942	.021653	.19041
9.2	.24740	.023302	.19813	8.6	.22941	.020122	.18444
9.0	.23770	.021749	.19224	8.4	.21996	.018710	.17863
8.8	.22850	.020307	.18650	8.2	.21099	.017401	.17297
8.6	.21972	.018964	.18091	8.0	.20245	.016185	.16746
8.4	.21133	.017709	.17543	7.8	.19429	.015052	.16207
8.2	.20328	.016535	.17008	7.6	.18646	.013994	.15679
8.0	.19554	.015433	.16483	7.4	.17894	.013004	.15163
7.8	.18808	.014398	.15968	7.2	.17170	.012077	.14656
7.6	.18088	.013425	.15462	7.0	.16472	.011206	.14158
7.4	.17392	.012509	.14965	6.8	.15796	.010389	.13669
7.2	.16718	.011645	.14475	6.6	.15142	.009621	.13188
7.0	.16064	.010830	.13994	6.4	.14508	.008898	.12715
6.8	.15428	.010061	.13519	6.2	.13892	.008218	.12248
6.6	.14811	.009336	.13052	6.0	.13294	.007578	.11788
6.4	.14209	.008650	.12590	5.8	.12711	.006976	.11335
6.2	.13623	.008003	.12135	5.6	.12143	.006409	.10887
6.0	.13051	.007392	.11686	5.4	.11590	.005876	.10446
5.8	.12493	.006815	.11242	5.2	.11049	.005374	.10010
5.6	.11947	.006270	.10803	5.0	.10521	.004903	.09579
5.4	.11413	.005756	.10370	4.8	.10004	.004460	.09152
5.2	.10891	.005271	.09941	4.6	.09499	.004044	.08731
5.0	.10380	.004815	.09517	4.4	.09004	.003655	.08314
4.8	.09878	.004385	.09097	4.2	.08519	.003290	.07901
4.6	.09387	.003981	.08681	4.0	.08043	.002949	.07493
4.4	.08904	.003601	.08270	3.8	.07577	.002631	.07088
4.2	.08431	.003245	.07862	3.6	.07119	.002335	.06687
4.0	.07966	.002912	.07458	3.4	.06669	.002060	.06290
3.8	.07509	.002600	.07058	3.2	.06227	.001805	.05897
3.6	.07060	.002310	.06661	3.0	.05793	.001570	.05507
3.4	.06618	.002039	.06267	2.8	.05366	.001354	.05120
3.2	.06183	.001789	.05877	2.6	.04945	.001156	.04737
3.0	.05755	.001557	.05490	2.4	.04532	.000975	.04357
2.8	.05333	.001343	.05106	2.2	.04124	.000811	.03979
2.6	.04918	.001147	.04725	2.0	.03723	.000664	.03605
2.4	.04509	.000969	.04346	1.8	.03327	.000533	.03233
2.2	.04106	.000807	.03971	1.6	.02937	.000417	.02864
2.0	.03708	.000661	.03598	1.4	.02553	.000316	.02497
1.8	.03316	.000530	.03227	1.2	.02174	.000230	.02133
1.6	.02929	.000415	.02859	1.0	.01800	.000159	.01772
1.4	.02547	.000315	.02494	0.8	.01431	.000101	.01413

$\gamma = 1.8$				$\gamma = 1.9$			
φ	X	Y	T	φ	X	Y	T
9.6°	.31398	.033273	.22453	9.0°	.28737	.028267	.20836
9.4	.29579	.030230	.21645	8.8	.27075	.025664	.20065
9.2	.27994	.027634	.20891	8.6	.25612	.023425	.19342
9.0	.26580	.025369	.20180	8.4	.24299	.021461	.18658
8.8	.25298	.023361	.19503	8.2	.23101	.019714	.18004
8.6	.24120	.021558	.18854	8.0	.21997	.018142	.17377
8.4	.23028	.019926	.18230	7.8	.20969	.016716	.16773
8.2	.22008	.018437	.17627	7.6	.20007	.015415	.16188
8.0	.21048	.017071	.17042	7.4	.19100	.014221	.15620
7.8	.20141	.015813	.16474	7.2	.18242	.013121	.15068
7.6	.19281	.014649	.15921	7.0	.17426	.012104	.14531
7.4	.18460	.013569	.15382	6.8	.16647	.011162	.14005
7.2	.17676	.012564	.14854	6.6	.15902	.010287	.13492
7.0	.16925	.011628	.14338	6.4	.15187	.009472	.12989
6.8	.16202	.010754	.13832	6.2	.14499	.008712	.12496
6.6	.15506	.009936	.13336	6.0	.13836	.008003	.12012
6.4	.14834	.009171	.12848	5.8	.13195	.007341	.11537
6.2	.14185	.008453	.12369	5.6	.12575	.006722	.11069
6.0	.13556	.007781	.11897	5.4	.11975	.006144	.10609
5.8	.12946	.007151	.11434	5.2	.11392	.005603	.10157
5.6	.12354	.006559	.10977	5.0	.10826	.005098	.09710
5.4	.11778	.006005	.10526	4.8	.10275	.004625	.09270
5.2	.11217	.005484	.10082	4.6	.09739	.004184	.08836
5.0	.10670	.004997	.09643	4.4	.09216	.003773	.08408
4.8	.10137	.004540	.09210	4.2	.08706	.003389	.07984
4.6	.09617	.004112	.08783	4.0	.08207	.003032	.07566
4.4	.09108	.003712	.08360	3.8	.07720	.002700	.07153
4.2	.08611	.003338	.07942	3.6	.07244	.002391	.06744
4.0	.08125	.002989	.07529	3.4	.06777	.002106	.06340
3.8	.07648	.002664	.07120	3.2	.06320	.001842	.05940
3.6	.07181	.002362	.06716	3.0	.05872	.001600	.05544
3.4	.06723	.002082	.06315	2.8	.05433	.001377	.05152
3.2	.06274	.001823	.05918	2.6	.05002	.001174	.04763
3.0	.05833	.001585	.05525	2.4	.04578	.000989	.04379
2.8	.05400	.001365	.05136	2.2	.04162	.000822	.03997
2.6	.04974	.001164	.04750	2.0	.03753	.000672	.03619
2.4	.04555	.000982	.04368	1.8	.03352	.000538	.03245
2.2	.04144	.000816	.03989	1.6	.02956	.000421	.02873
2.0	.03739	.000668	.03612	1.4	.02567	.000319	.02504
1.8	.03340	.000536	.03239	1.2	.02184	.000232	.02139
1.6	.02947	.000419	.02869	1.0	.01807	.000160	.01776
1.4	.02560	.000318	.02501	0.8	.01435	.000102	.01416
1.2	.02179	.000231	.02136	0.6	.01069	.000057	.01058
1.0	.01803	.000159	.01774	0.4	.00708	.000025	.00703
0.8	.01433	.000101	.01415	+.2	.00352	.000006	.00350
0.6	.01068	.000056	.01058	0.0	.00000	.000000	.00000
0.4	.00708	.000024	.00703	−.2	.00347	.000006	.00348
0.2	.00352	[illegible]	00350	0.4	.00689	.000024	.00694

$\gamma = 2.0$				$\gamma = 2.1$			
φ	X	Y	T	φ	X	Y	T
8°.6	.27661	.026059	.19960	8°.2	.26354	.023652	.19018
8.4	.25962	.023518	.19182	8 0	.24666	.021250	.18243
8.2	.24482	.021358	.18455	7.8	.23203	.019219	.17522
8.0	.23162	.019478	.17769	7.6	.21901	.017459	.16842
7.8	.21964	.017816	.17117	7.4	.20724	.015908	.16195
7.6	.20864	.016328	.16491	7.2	.19644	.014525	.15576
7.4	.19843	.014985	.15889	7.0	.18644	.013279	.14981
7.2	.18890	.013763	.15308	6.8	.17711	.012149	.14406
7.0	.17994	.012646	.14744	6.6	.16834	.011119	.13849
6.8	.17146	.011621	.14196	6.4	.16005	.010175	.13308
6.6	.16342	.010676	.13663	6.2	.15220	.009308	.12781
6.4	.15575	.009802	.13142	6.0	.14471	.008508	.12267
6.2	.14843	.008993	.12633	5.8	.13756	.007769	.11764
6.0	.14140	.008242	.12135	5.6	.13071	.007085	.11273
5.8	.13465	.007544	.11647	5.4	.12412	.006451	.10791
5.6	.12815	.006895	.11168	5.2	.11778	.005862	.10319
5.4	.12187	.006291	.10698	5.0	.11167	.005316	.09855
5.2	.11580	.005727	.10236	4.8	.10575	.004809	.09399
5.0	.10992	.005203	.09781	4 6	.10002	.004338	.08950
4.8	.10422	.004714	.09333	4.4	.09447	.003901	.08508
4.6	.09868	.004259	.08892	4.2	.08908	.003496	.08073
4.4	.09329	.003835	.08457	4.0	.08383	.003120	.07645
4.2	.08805	.003441	.08028	3.8	.07873	.002772	.07222
4.0	.08294	.003074	.07605	3.6	.07376	.002450	.06804
3.8	.07796	.002734	.07187	3.4	.06891	.002153	.06392
3.6	.07309	.002420	.06774	3.2	.06418	.001880	.05985
3.4	.06834	.002129	.06366	3.0	.05955	.001630	.05582
3.2	.06369	.001861	.05962	2.8	.05503	.001400	.05184
3.0	.05914	.001615	.05563	2.6	.05060	.001192	.04791
2.8	.05468	.001389	.05168	2.4	.04627	.001003	.04402
2.6	.05031	.001183	.04777	2.2	.04202	.000832	.04016
2.4	.04603	.000996	.04390	2.0	.03785	.000679	.03635
2.2	.04182	.000827	.04007	1.8	.03377	.000544	.03257
2.0	.03770	.000675	.03627	1.6	.02976	.000425	.02883
1.8	.03364	.000541	.03251	1.4	.02582	.000322	.02512
1.6	.02966	.000423	.02878	1.2	.02194	.000234	.02144
1.4	.02575	.000320	.02508	1.0	.01814	.000161	.01779
1.2	.02189	.000233	.02141	0.8	.01440	.000102	.01418
1.0	.01811	.000160	.01778	0.6	.01071	.000057	.01059
0.8	.01438	.000102	.01417	0.4	.00709	.000025	.00703
0.6	.01071	.000057	.01059	+.2	.00352	.000006	.00350
0.4	.00709	.000025	.00704	0.0	.00000	.000000	.00000
+.2	.00352	.000006	.00351	−.2	.00347	.000006	.00347
0.0	.00000	.000000	.00000	0.4	.00689	.000024	.00692
−.2	.00345	.000006	.00348	0.6	.01026	.000053	.01035
0.4	.00686	.000024	.00694	0.8	.01358	.000094	.01376
0.6	.01024	.000053	.01037	1.0	.01685	.000145	.01715
0.8	.01358	.000094	.01378	1.2	.02008	.000207	.02051

γ = 2.2				γ = 2.3			
φ	X	Y	T	φ	X	Y	T
8°.0	.26801	.023841	.18851	7°.6	.25022	.020996	.17785
7.8	.24848	.021130	.18019	7.4	.23197	.018592	.16980
7.6	.23217	.018925	.17259	7.2	.21660	.016622	.16241
7.4	.21803	.017062	.16550	7.0	.20318	.014950	.15552
7.2	.20544	.015449	.15882	6.8	.19120	.013500	.14900
7.0	.19404	.014029	.15246	6.6	.18032	.012221	.14280
6.8	.18359	.012764	.14638	6.4	.17031	.011081	.13685
6.6	.17390	.011626	.14053	6.2	.16104	.010057	.13113
6.4	.16486	.010596	.13487	6.0	.15236	.009129	.12559
6.2	.15637	.009658	.12940	5.8	.14420	.008286	.12023
6.0	.14834	.008800	.12407	5.6	.13648	.007516	.11501
5.8	.14073	.008013	.11889	5.4	.12916	.006810	.10993
5.6	.13348	.007289	.11383	5.2	.12217	.006162	.10497
5.4	.12654	.006622	.10889	5.0	.11550	.005566	.10012
5.2	.11990	.006005	.10405	4.8	.10909	.005017	.09538
5.0	.11352	.005436	.09932	4.6	.10294	.004511	.09073
4.8	.10737	.004909	.09467	4.4	.09701	.004044	.08616
4.6	.10144	.004421	.09010	4.2	.09128	.003613	.08168
4.4	.09571	.003970	.08561	4.0	.08575	.003216	.07727
4.2	.09016	.003552	.08120	3.8	.08038	.002850	.07294
4.0	.08477	.003166	.07685	3.6	.07518	.002514	.06866
3.8	.07954	.002810	.07257	3.4	.07013	.002205	.06446
3.6	.07446	.002481	.06835	3.2	.06521	.001921	.06031
3.4	.06951	.002178	.06419	3.0	.06043	.001662	.05622
3.2	.06469	.001900	.06008	2.8	.05576	.001426	.05218
3.0	.05998	.001645	.05602	2.6	.05121	.001212	.04819
2.8	.05539	.001412	.05201	2.4	.04677	.001018	.04424
2.6	.05090	.001201	.04805	2.2	.04243	.000843	.04035
2.4	.04651	.001009	.04413	2.0	.03818	.000687	.03649
2.2	.04222	.000837	.04026	1.8	.03402	.000550	.03268
2.0	.03802	.000683	.03642	1.6	.02995	.000429	.02891
1.8	.03389	.000546	.03263	1.4	.02596	.000324	.02518
1.6	.02985	.000426	.02887	1.2	.02205	.000235	.02149
1.4	.02589	.000322	.02515	1.0	.01821	.000162	.01782
1.2	.02200	.000234	.02146	0.8	.01444	.000102	.01420
1.0	.01817	.000161	.01781	0.6	.01074	.000057	.01060
0.8	.01442	.000102	.01419	0.4	.00710	.000025	.00704
0.6	.01072	.000057	.01060	+.2	.00352	.000006	.00351
0.4	.00709	.000025	.00704	0.0	.00000	.000000	.00000
+.2	.00352	.000006	.00351	−.2	.00346	.000006	.00348
0.0	.00000	.000000	.00000	0.4	.00687	.000024	.00693
−.2	.00347	.000006	.00348	0.6	.01023	.000053	.01035
0.4	.00689	.000024	.00694	0.8	.01354	.000094	.01375
0.6	.01026	.000053	.01037	1.0	.01680	.000145	.01712
0.8	.01357	.000094	.01377	1.2	.02002	.000206	.02047
1.0	.01683	.000145	.01714	1.4	.02319	.000277	.02380
1.2	.02005	.000207	.02049	1.6	.02632	.000359	.02711
1.4	.02323	.000280	.02382	1.8	.02940	.000451	.03039

$\gamma = 2.4$				$\gamma = 2.5$			
φ	X	Y	T	φ	X	Y	T
7.4	.25182	.020836	.17534	7.0	.23004	.017756	.16361
7.2	.23130	.018206	.16682	6.8	.21205	.015577	.15563
7.0	.21464	.016130	.15914	6.6	.19704	.013813	.14834
6.8	.20040	.014406	.15204	6.4	.18402	.012329	.14155
6.6	.18786	.012933	.14538	6.2	.17243	.011049	.13515
6.4	.17660	.011649	.13906	6.0	.16193	.009927	.12907
6.2	.16632	.010514	.13304	5.8	.15231	.008933	.12324
6.0	.15685	.009501	.12726	5.6	.14340	.008043	.11764
5.8	.14803	.008590	.12168	5.4	.13508	.007241	.11222
5.6	.13977	.007765	.11628	5.2	.12726	.006516	.10697
5.4	.13198	.007016	.11104	5.0	.11987	.005856	.10188
5.2	.12461	.006332	.10595	4.8	.11286	.005255	.09691
5.0	.11760	.005706	.10098	4.6	.10618	.004706	.09207
4.8	.11091	.005132	.09613	4.4	.09980	.004204	.08733
4.6	.10451	.004606	.09139	4.2	.09369	.003744	.08270
4.4	.09836	.004122	.08674	4.0	.08781	.003322	.07816
4.2	.09245	.003677	.08219	3.8	.08215	.002937	.07370
4.0	.08675	.003269	.07772	3.6	.07669	.002583	.06933
3.8	.08125	.002893	.07332	3.4	.07141	.002260	.06503
3.6	.07592	.002549	.06900	3.2	.06630	.001965	.06079
3.4	.07076	.002232	.06475	3.0	.06134	.001696	.05663
3.2	.06574	.001943	.06056	2.8	.05652	.001452	.05252
3.0	.06087	.001680	.05643	2.6	.05184	.001232	.04848
2.8	.05614	.001439	.05236	2.4	.04728	.001032	.04448
2.6	.05152	.001222	.04834	2.2	.04284	.000854	.04054
2.4	.04702	.001025	.04437	2.0	.03851	.000695	.03665
2.2	.04263	.000849	.04045	1.8	.03428	.000555	.03281
2.0	.03834	.000692	.03658	1.6	.03015	.000432	.02901
1.8	.03415	.000553	.03275	1.4	.02611	.000326	.02525
1.6	.03005	.000431	.02897	1.2	.02215	.000237	.02154
1.4	.02603	.000325	.02522	1.0	.01828	.000162	.01786
1.2	.02210	.000236	.02152	0.8	.01448	.000102	.01422
1.0	.01824	.000162	.01785	0.6	.01076	.000057	.01062
0.8	.01446	.000102	.01421	0.4	.00711	.000025	.00704
0.6	.01075	.000057	.01061	+.2	.00352	.000006	.00351
0.4	.00710	.000025	.00704	0.0	.00000	.000000	.00000
+.2	.00352	.000006	.00351	−.2	.00346	.000006	.00348
0.0	.00000	.000000	.00000	0.4	.00686	.000024	.00692
−.2	.00346	.000006	.00348	0.6	.01021	.000053	.01034
0.4	.00687	.000024	.00693	0.8	.01350	.000093	.01373
0.6	.01022	.000053	.01035	1.0	.01675	.000144	.01710
0.8	.01352	.000094	.01374	1.2	.01995	.000205	.02044
1.0	.01677	.000145	.01711	1.4	.02310	.000276	.02376
1.2	.01998	.000206	.02045	1.6	.02620	.000357	.02705
1.4	.02314	.000277	.02377	1.8	.02925	.000448	.03031
1.6	.02626	.000358	.02707	2.0	.03225	.000548	.03355
1.8	.02933	.000449	.03035	2.2	.03521	.000657	.03677
2.0	.03235	.000551	.03360	2.4	.03814	.000775	.03997

$\gamma = 2.6$				$\gamma = 2.7$			
φ	X	Y	T	φ	X	Y	T
6.6°	.20876	.014962	.15189	6.4°	.20465	.014281	.14792
6.4	.19307	.013173	.14445	6.2	.18842	.012488	.14035
6.2	.17964	.011690	.13756	6.0	.17470	.011021	.13339
6.0	.16780	.010425	.13110	5.8	.16271	.009782	.12689
5.8	.15716	.009324	.12497	5.6	.15199	.008711	.12074
5.6	.14744	.008355	.11912	5.4	.14224	.007773	.11488
5.4	.13848	.007491	.11350	5.2	.13328	.006941	.10927
5.2	.13014	.006717	.10808	5.0	.12496	.006198	.10386
5.0	.12232	.006019	.10283	4.8	.11718	.005531	.09862
4.8	.11494	.005387	.09774	4.6	.10985	.004929	.09355
4.6	.10796	.004813	.09279	4.4	.10293	.004383	.08862
4.4	.10132	.004290	.08796	4.2	.09635	.003889	.08381
4.2	.09499	.003814	.08324	4.0	.09007	.003439	.07912
4.0	.08892	.003379	.07863	3.8	.08407	.003030	.07453
3.8	.08309	.002982	.07411	3.6	.07832	.002657	.07004
3.6	.07749	.002620	.06968	3.4	.07278	.002319	.06564
3.4	.07209	.002289	.06533	3.2	.06745	.002011	.06132
3.2	.06687	.001988	.06105	3.0	.06230	.001732	.05707
3.0	.06182	.001714	.05685	2.8	.05732	.001480	.05290
2.8	.05692	.001466	.05271	2.6	.05250	.001253	.04879
2.6	.05217	.001242	.04863	2.4	.04782	.001048	.04474
2.4	.04756	.001040	.04461	2.2	.04327	.000866	.04075
2.2	.04306	.000860	.04065	2.0	.03885	.000704	.03682
2.0	.03869	.000699	.03674	1.8	.03455	.000561	.03294
1.8	.03442	.000558	.03288	1.6	.03035	.000436	.02911
1.6	.03026	.000434	.02906	1.4	.02626	.000329	.02533
1.4	.02619	.000328	.02529	1.2	.02226	.000238	.02159
1.2	.02221	.000237	.02156	1.0	.01835	.000163	.01790
1.0	.01832	.000163	.01788	0.8	.01453	.000103	.01424
0.8	.01451	.000103	.01423	0.6	.01078	.000057	.01063
0.6	.01077	.000057	.01062	0.4	.00712	.000025	.00705
0.4	.00711	.000025	.00705	+.2	.00352	.000006	.00351
+.2	.00352	.000006	.00351	0.0	.00000	.000000	.00000
0.0	.00000	.000000	.00000	−.2	.00346	.000006	.00348
−.2	.00346	.000006	.00348	0.4	.00686	.000024	.00692
0.4	.00686	.000024	.00692	0.6	.01019	.000053	.01033
0.6	.01020	.000053	.01034	0.8	.01347	.000093	.01371
0.8	.01349	.000093	.01372	1.0	.01669	.000144	.01707
1.0	.01672	.000144	.01708	1.2	.01986	.000204	.02040
1.2	.01990	.000205	.02042	1.4	.02298	.000274	.02370
1.4	.02303	.000276	.02373	1.6	.02606	.000354	.02698
1.6	.02612	.000357	.02701	1.8	.02909	.000444	.03023
1.8	.02916	.000447	.03027	2.0	.03207	.000544	.03345
2.0	.03216	.000547	.03350	2.2	.03501	.000652	.03665
2.2	.03512	.000656	.03671	2.4	.03791	.000769	.03983
2.4	.03804	.000773	.03990	2.6	.04077	.000894	.04299
2.6	.04092	.000898	.04307	2.8	.04359	.001027	.04614
2.8	.04376	[illegible]	04622	3.0	.04636	.001167	.04927

γ = 2.8				γ = 2.9			
φ	X	Y	T	φ	X	Y	T
6.2°	.19970	.013534	.14368	6.0°	.19388	.012730	.13921
6.0	.18312	.011761	.13603	5.8	.17717	.011002	.13154
5.8	.16925	.010328	.12903	5.6	.16330	.009618	.12455
5.6	.15721	.009125	.12252	5.4	.15131	.008463	.11805
5.4	.14649	.008092	.11637	5.2	.14067	.007475	.11193
5.2	.13678	.007191	.11053	5.0	.13105	.006616	.10611
5.0	.12786	.006395	.10493	4.8	.12223	.005861	.10054
4.8	.11961	.005687	.09954	4.6	.11408	.005190	.09519
4.6	.11190	.005053	.09433	4.4	.10647	.004591	.09002
4.4	.10465	.004483	.08929	4.2	.09933	.004054	.08501
4.2	.09780	.003968	.08439	4.0	.09258	.003570	.08015
4.0	.09130	.003502	.07961	3.8	.08618	.003134	.07541
3.8	.08511	.003080	.07495	3.6	.08009	.002739	.07079
3.6	.07919	.002697	.07040	3.4	.07427	.002383	.06628
3.4	.07352	.002350	.06594	3.2	.06870	.002062	.06186
3.2	.06807	.002036	.06157	3.0	.06334	.001772	.05753
3.0	.06282	.001751	.05728	2.8	.05818	.001510	.05328
2.8	.05775	.001495	.05307	2.6	.05320	.001275	.04910
2.6	.05285	.001264	.04893	2.4	.04839	.001065	.04500
2.4	.04811	.001056	.04486	2.2	.04373	.000878	.04096
2.2	.04350	.000872	.04085	2.0	.03921	.000712	.03699
2.0	.03903	.000708	.03689	1.8	.03483	.000566	.03307
1.8	.03469	.000564	.03300	1.6	.03056	.000440	.02921
1.6	.03046	.000438	.02915	1.4	.02641	.000331	.02540
1.4	.02634	.000330	.02536	1.2	.02237	.000239	.02165
1.2	.02232	.000238	.02161	1.0	.01842	.000164	.01793
1.0	.01839	.000163	.01791	0.8	.01457	.000103	.01427
0.8	.01455	.000103	.01425	0.6	.01081	.000057	.01064
0.6	.01080	.000057	.01063	0.4	.00713	.000025	.00706
0.4	.00712	.000025	.00705	+.2	.00353	.000006	.00351
+.2	.00353	.000006	.00351	0.0	.00000	.000000	.00000
0.0	.00000	.000000	.00000	−.2	.00346	.000006	.00347
−.2	.00346	.000006	.00347	0.4	.00685	.000024	.00691
0.4	.00685	.000024	.00692	0.6	.01017	.000052	.01032
0.6	.01018	.000053	.01033	0.8	.01343	.000092	.01369
0.8	.01345	.000093	.01371	1.0	.01664	.000143	.01704
1.0	.01667	.000143	.01706	1.2	.01979	.000203	.02036
1.2	.01983	.000203	.02038	1.4	.02289	.000273	.02364
1.4	.02294	.000273	.02368	1.6	.02594	.000353	.02691
1.6	.02600	.000353	.02695	1.8	.02893	.000442	.03014
1.8	.02901	.000443	.03019	2.0	.03188	.000540	.03335
2.0	.03197	.000542	.03341	2.2	.03479	.000646	.03654
2.2	.03489	.000649	.03661	2.4	.03766	.000760	.03970
2.4	.03777	.000765	.03978	2.6	.04048	.000883	.04284
2.6	.04061	.000889	.04293	2.8	.04326	.001015	.04596
2.8	.04342	.001021	.04606	3.0	.04600	.001155	.04906
3.0	.04618	.001161	.04917	3.2	.04871	.001303	.05214
3.2	.04890	.001308	.05226	3.4	.05138	.001458	.05520

γ = 3.0				γ = 3.1			
φ	X	Y	T	φ	X	Y	T
$\overset{\circ}{5.6}$	.17062	.010218	.12684	$\overset{\circ}{5.6}$	.17983	.010990	.12957
5.4	.15690	.008897	.11989	5.4	.16358	.009425	.12201
5.2	.14506	.007798	.11344	5.2	.15014	.008177	.11513
5.0	.13457	.006862	.10736	5.0	.13855	.007143	.10875
4.8	.12510	.006050	.10159	4.8	.12829	.006262	.10274
4.6	.11644	.005337	.09608	4.6	.11901	.005499	.09703
4.4	.10842	.004706	.09077	4.4	.11053	.004831	.09157
4.2	.10094	.004144	.08565	4.2	.10268	.004241	.08632
4.0	.09393	.003641	.08068	4.0	.09536	.003716	.08126
3.8	.08731	.003189	.07586	3.8	.08849	.003248	.07635
3.6	.08103	.002783	.07117	3.6	.08201	.002829	.07158
3.4	.07505	.002417	.06660	3.4	.07587	.002453	.06694
3.2	.06934	.002088	.06212	3.2	.07001	.002115	.06241
3.0	.06387	.001791	.05775	3.0	.06442	.001812	.05799
2.8	.05861	.001525	.05346	2.8	.05907	.001541	.05366
2.6	.05355	.001287	.04925	2.6	.05393	.001298	.04942
2.4	.04867	.001074	.04512	2.4	.04897	.001082	.04526
2.2	.04396	.000884	.04106	2.2	.04420	.000890	.04117
2.0	.03939	.000717	.03707	2.0	.03958	.000721	.03715
1.8	.03497	.000570	.03313	1.8	.03511	.000573	.03320
1.6	.03067	.000442	.02926	1.6	.03078	.000444	.02931
1.4	.02649	.000332	.02543	1.4	.02657	.000334	.02548
1.2	.02242	.000240	.02167	1.2	.02248	.000241	.02170
1.0	.01846	.000164	.01795	1.0	.01850	.000165	.01797
0.8	.01459	.000103	.01427	0.8	.01462	.000104	.01429
0.6	.01082	.000057	.01064	0.6	.01083	.000057	.01065
0.4	.00713	.000025	.00706	0.4	.00714	.000025	.00706
+.2	.00353	.000006	.00351	+.2	.00353	.000006	.00351
0.0	.00000	.000000	.00000	0.0	.00000	.000000	.00000
−.2	.00346	.000006	.00347	−.2	.00345	.000006	.00347
0.4	.00684	.000024	.00691	0.4	.00684	.000024	.00691
0.6	.01016	.000053	.01032	0.6	.01015	.000052	.01031
0.8	.01342	.000092	.01369	0.8	.01340	.000092	.01368
1.0	.01662	.000142	.01703	1.0	.01659	.000142	.01701
1.2	.01976	.000203	.02034	1.2	.01972	.000202	.02032
1.4	.02284	.000273	.02363	1.4	.02279	.000272	.02360
1.6	.02587	.000352	.02688	1.6	.02581	.000351	.02684
1.8	.02886	.000441	.03011	1.8	.02878	.000439	.03006
2.0	.03179	.000538	.03331	2.0	.03171	.000536	.03326
2.2	.03468	.000646	.03649	2.2	.03458	.000641	.03643
2.4	.03753	.000761	.03964	2.4	.03741	.000755	.03957
2.6	.04034	.000883	.04277	2.6	.04019	.000876	.04270
2.8	.04310	.001012	.04588	2.8	.04294	.001006	.04579
3.0	.04582	.001149	.04897	3.0	.04564	.001143	.04887
3.2	.04850	.001295	.05204	3.2	.04830	.001288	·05193
3.4	.05115	.001448	.05509	3.4	.05093	.001440	.05497
3.6	.05377	.001608	.05812	3.6	.05353	.001599	.05799
3.8	.05635	.001775	.06113	3.8	.05609	.001764	.06098

$\gamma = 3.2$				$\gamma = 3.3$			
φ	X	Y	T	φ	X	Y	T
5.2°	.15612	.008631	.11704	5.2°	.16339	.009192	.11926
5.0	.14309	.007467	.11027	5.0	.14836	.007850	.11199
4.8	.13183	.006502	.10398	4.8	.13583	.006775	.10535
4.6	.12184	.005680	.09805	4.6	.12496	.005880	.09917
4.4	.11281	.004969	.09242	4.4	.11529	.005119	.09334
4.2	.10454	.004347	.08703	4.2	.10653	.004460	.08780
4.0	.09689	.003798	.08185	4.0	.09850	.003885	.08249
3.8	.08975	.003311	.07685	3.8	.09107	.003377	.07738
3.6	.08304	.002878	.07200	3.6	.08412	.002928	.07245
3.4	.07671	.002490	.06729	3.4	.07760	.002529	.06766
3.2	.07071	.002144	.06271	3.2	.07143	.002174	.06301
3.0	.06400	.001835	.05824	3.0	.06559	.001857	.05849
2.8	.05954	.001558	.05387	2.8	.06002	.001575	.05407
2.6	.05431	.001311	.04959	2.6	.05469	.001323	.04976
2.4	.04928	.001092	.04539	2.4	.04959	.001101	.04553
2.2	.04444	.000897	.04128	2.2	.04468	.000904	.04139
2.0	.03977	.000726	.03724	2.0	.03996	.000730	.03733
1.8	.03526	.000576	.03327	1.8	.03540	.000579	.03334
1.6	.03089	.000446	.02936	1.6	.03100	.000448	.02941
1.4	.02665	.000335	.02551	1.4	.02673	.000336	.02555
1.2	.02253	.000242	.02172	1.2	.02259	.000243	.02175
1.0	.01853	.000165	.01799	1.0	.01857	.000165	.01800
0.8	.01464	.000104	.01430	0.8	.01466	.000104	.01431
0.6	.01085	.000058	.01066	0.6	.01086	.000057	.01066
0.4	.00714	.000025	.00706	0.4	.00715	.000025	.00706
+.2	.00353	.000006	.00351	+.2	.00353	.000006	.00351
0.0	.00000	.000000	.00000	0.0	.00000	.000000	.00000
−.2	.00345	.000006	.00347	−.2	.00345	.000006	.00347
0.4	.00683	.000024	.00691	0.4	.00683	.000024	.00690
0.6	.01014	.000053	.01030	0.6	.01013	.000052	.01030
0.8	.01338	.000092	.01367	0.8	.01337	.000092	.01366
1.0	.01656	.000142	.01700	1.0	.01654	.000142	.01698
1.2	.01968	.000202	.02030	1.2	.01965	.000201	.02028
1.4	.02275	.000272	.02357	1.4	.02270	.000271	.02354
1.6	.02575	.000350	.02681	1.6	.02569	.000349	.02678
1.8	.02871	.000438	.03003	1.8	.02864	.000436	.02999
2.0	.03162	.000535	.03321	2.0	.03153	.000532	.03317
2.2	.03447	.000639	.03637	2.2	.03437	.000636	.03632
2.4	.03729	.000752	.03951	2.4	.03717	.000749	.03945
2.6	.04006	.000873	.04262	2.6	.03992	.000869	.04255
2.8	.04278	.001001	.04571	2.8	.04263	.000997	.04563
3.0	.04547	.001137	.04878	3.0	.04530	.001132	.04869
3.2	.04812	.001280	.05183	3.2	.04793	.001274	.05173
3.4	.05073	.001430	.05486	3.4	.05052	.001423	.05474
3.6	.05331	.001587	.05786	3.6	.05308	.001579	.05773
3.8	.05585	.001752	.06084	3.8	.05560	.001742	.06070
4.0	.05835	.001924	.06380	4.0	.05808	.001912	.06365
4.2	.06082	.002102	.06675	4.2	.06053	.002088	.06658

γ = 3.0				γ = 3.1			
φ	X	Y	T	φ	X	Y	T
5°.6	.17062	.010218	.12684	5°.6	.17983	.010990	.12957
5.4	.15690	.008897	.11989	5.4	.16358	.009425	.12201
5.2	.14506	.007798	.11344	5.2	.15014	.008177	.11513
5.0	.13457	.006862	.10736	5.0	.13855	.007143	.10875
4.8	.12510	.006050	.10159	4.8	.12829	.006262	.10274
4.6	.11644	.005337	.09608	4.6	.11901	.005499	.09703
4.4	.10842	.004706	.09077	4.4	.11053	.004831	.09157
4.2	.10094	.004144	.08565	4.2	.10268	.004241	.08632
4.0	.09393	.003641	.08068	4.0	.09536	.003716	.08126
3.8	.08731	.003189	.07586	3.8	.08849	.003248	.07635
3.6	.08103	.002783	.07117	3.6	.08201	.002829	.07158
3.4	.07505	.002417	.06660	3.4	.07587	.002453	.06694
3.2	.06934	.002088	.06212	3.2	.07001	.002115	.06241
3.0	.06387	.001791	.05775	3.0	.06442	.001812	.05799
2.8	.05861	.001525	.05346	2.8	.05907	.001541	.05366
2.6	.05355	.001287	.04925	2.6	.05393	.001298	.04942
2.4	.04867	.001074	.04512	2.4	.04897	.001082	.04526
2.2	.04396	.000884	.04106	2.2	.04420	.000890	.04117
2.0	.03939	.000717	.03707	2.0	.03958	.000721	.03715
1.8	.03497	.000570	.03313	1.8	.03511	.000573	.03320
1.6	.03067	.000442	.02926	1.6	.03078	.000444	.02931
1.4	.02649	.000332	.02543	1.4	.02657	.000334	.02548
1.2	.02242	.000240	.02167	1.2	.02248	.000241	.02170
1.0	.01846	.000164	.01795	1.0	.01850	.000165	.01797
0.8	.01459	.000103	.01427	0.8	.01462	.000104	.01429
0.6	.01082	.000057	.01064	0.6	.01083	.000057	.01065
0.4	.00713	.000025	.00706	0.4	.00714	.000025	.00706
+.2	.00353	.000006	.00351	+.2	.00353	.000006	.00351
0.0	.00000	.000000	.00000	0.0	.00000	.000000	.00000
−.2	.00346	.000006	.00347	−.2	.00345	.000006	.00347
0.4	.00684	.000024	.00691	0.4	.00684	.000024	.00691
0.6	.01016	.000053	.01032	0.6	.01015	.000052	.01031
0.8	.01342	.000092	.01369	0.8	.01340	.000092	.01368
1.0	.01662	.000142	.01703	1.0	.01659	.000142	.01701
1.2	.01976	.000203	.02034	1.2	.01972	.000202	.02032
1.4	.02284	.000273	.02363	1.4	.02279	.000272	.02360
1.6	.02587	.000352	.02688	1.6	.02581	.000351	.02684
1.8	.02886	.000441	.03011	1.8	.02878	.000439	.03006
2.0	.03179	.000538	.03331	2.0	.03171	.000536	.03326
2.2	.03468	.000646	.03649	2.2	.03458	.000641	.03643
2.4	.03753	.000761	.03964	2.4	.03741	.000755	.03957
2.6	.04034	.000883	.04277	2.6	.04019	.000876	.04270
2.8	.04310	.001012	.04588	2.8	.04294	.001006	.04579
3.0	.04582	.001149	.04897	3.0	.04564	.001143	.04887
3.2	.04850	.001295	.05204	3.2	.04830	.001288	.05193
3.4	.05115	.001448	.05509	3.4	.05093	.001440	.05497
3.6	.05377	.001608	.05812	3.6	.05353	.001599	.05799
3.8	.05635	.001775	.06113	3.8	.05609	.001764	.06098

$\gamma = 3.2$				$\gamma = 3.3$			
φ	X	Y	T	φ	X	Y	T
5.2°	.15612	.008631	.11704	5.2°	.16339	.009192	.11926
5.0	.14309	.007467	.11027	5.0	.14836	.007850	.11199
4.8	.13183	.006502	.10398	4.8	.13583	.006775	.10535
4.6	.12184	.005680	.09805	4.6	.12496	.005880	.09917
4.4	.11281	.004969	.09242	4.4	.11529	.005119	.09334
4.2	.10454	.004347	.08703	4.2	.10653	.004460	.08780
4.0	.09689	.003798	.08185	4.0	.09850	.003885	.08249
3.8	.08975	.003311	.07685	3.8	.09107	.003377	.07738
3.6	.08304	.002878	.07200	3.6	.08412	.002928	.07245
3.4	.07671	.002490	.06729	3.4	.07760	.002529	.06766
3.2	.07071	.002144	.06271	3.2	.07143	.002174	.06301
3.0	.06400	.001835	.05824	3.0	.06559	.001857	.05849
2.8	.05954	.001558	.05387	2.8	.06002	.001575	.05407
2.6	.05431	.001311	.04959	2.6	.05469	.001323	.04976
2.4	.04928	.001092	.04539	2.4	.04959	.001101	.04553
2.2	.04444	.000897	.04128	2.2	.04468	.000904	.04139
2.0	.03977	.000726	.03724	2.0	.03996	.000730	.03733
1.8	.03526	.000576	.03327	1.8	.03540	.000579	.03334
1.6	.03089	.000446	.02936	1.6	.03100	.000448	.02941
1.4	.02665	.000335	.02551	1.4	.02673	.000336	.02555
1.2	.02253	.000242	.02172	1.2	.02259	.000243	.02175
1.0	.01853	.000165	.01799	1.0	.01857	.000165	.01800
0.8	.01464	.000104	.01430	0.8	.01466	.000104	.01431
0.6	.01085	.000058	.01066	0.6	.01086	.000057	.01066
0.4	.00714	.000025	.00706	0.4	.00715	.000025	.00706
+.2	.00353	.000006	.00351	+.2	.00353	.000006	.00351
0.0	.00000	.000000	.00000	0.0	.00000	.000000	.00000
−.2	.00345	.000006	.00347	−.2	.00345	.000006	.00347
0.4	.00683	.000024	.00691	0.4	.00683	.000024	.00690
0.6	.01014	.000053	.01030	0.6	.01013	.000052	.01030
0.8	.01338	.000092	.01367	0.8	.01337	.000092	.01366
1.0	.01656	.000142	.01700	1.0	.01654	.000142	.01698
1.2	.01968	.000202	.02030	1.2	.01965	.000201	.02028
1.4	.02275	.000272	.02357	1.4	.02270	.000271	.02354
1.6	.02575	.000350	.02681	1.6	.02569	.000349	.02678
1.8	.02871	.000438	.03003	1.8	.02864	.000436	.02999
2.0	.03162	.000535	.03321	2.0	.03153	.000532	.03317
2.2	.03447	.000639	.03637	2.2	.03437	.000636	.03632
2.4	.03729	.000752	.03951	2.4	.03717	.000749	.03945
2.6	.04006	.000873	.04262	2.6	.03992	.000869	.04255
2.8	.04278	.001001	.04571	2.8	.04263	.000997	.04563
3.0	.04547	.001137	.04878	3.0	.04530	.001132	.04869
3.2	.04812	.001280	.05183	3.2	.04793	.001274	.05173
3.4	.05073	.001430	.05486	3.4	.05052	.001423	.05474
3.6	.05331	.001587	.05786	3.6	.05308	.001579	.05773
3.8	.05585	.001752	.06084	3.8	.05560	.001742	.06070
4.0	.05835	.001924	.06380	4.0	.05808	.001912	.06365
4.2	.06082	.002102	.06675	4.2	.06053	.002088	.06658

$\gamma = 3.4$				$\gamma = 3.5$			
φ	X	Y	T	φ	X	Y	T
5°.0	.15467	.008315	.11392	4°.8	.14583	.007473	.10854
4.8	.14042	.007093	.10685	4.6	.13241	.006369	.10167
4.6	.12845	.006108	.10036	4.4	.12102	.005473	.09535
4.4	.11801	.005286	.09430	4.2	.11104	.004722	.08943
4.2	.10869	.004585	.08859	4.0	.10210	.004080	.08383
4.0	.10023	.003979	.08314	3.8	.09395	.003525	.07849
3.8	.09246	.003449	.07792	3.6	.08646	.003040	.07336
3.6	.08525	.002983	.07289	3.4	.07949	.002614	.06842
3.4	.07852	.002570	.06803	3.2	.07297	.002238	.06364
3.2	.07218	.002205	.06332	3.0	.06683	.001905	.05901
3.0	.06619	.001881	.05875	2.8	.06102	.001611	.05450
2.8	.06051	.001592	.05428	2.6	.05550	.001350	.05010
2.6	.05508	.001337	.04993	2.4	.05023	.001120	.04581
2.4	.04990	.001110	.04567	2.2	.04519	.000918	.04161
2.2	.04493	.000910	.04150	2.0	.04036	.000740	.03750
2.0	.04015	.000735	.03742	1.8	.03571	.000586	.03347
1.8	.03555	.000582	.03340	1.6	.03122	.000453	.02952
1.6	.03111	.000451	.02946	1.4	.02689	.000340	.02563
1.4	.02681	.000338	.02559	1.2	.02270	.000244	.02180
1.2	.02265	.000244	.02178	1.0	.01865	.000166	.01804
1.0	.01861	.000166	.01802	0.8	.01471	.000105	.01433
0.8	.01468	.000104	.01432	0.6	.01088	.000058	.01067
0.6	.01087	.000058	.01067	0.4	.00716	.000025	.00707
0.4	.00715	.000025	.00707	+.2	.00354	.000006	.00351
+.2	.00353	.000006	.00351	0.0	.00000	.000000	.00000
0.0	.00000	.000000	.00000	−.2	.00345	.000006	.00347
−.2	.00345	.000006	.00347	0.4	.00682	.000024	.00690
0.4	.00682	.000024	.00690	0.6	.01011	.000052	.01029
0.6	.01012	.000052	.01029	0.8	.01333	.000092	.01365
0.8	.01335	.000092	.01365	1.0	.01649	.000141	.01696
1.0	.01651	.000141	.01697	1.2	.01958	.000201	.02025
1.2	.01961	.000201	.02026	1.4	.02260	.000269	.02350
1.4	.02265	.000271	.02352	1.6	.02558	.000347	.02672
1.6	.02563	.000349	.02675	1.8	.02849	.000434	.02991
1.8	.02856	.000436	.02995	2.0	.03135	.000529	.03307
2.0	.03144	.000531	.03312	2.2	.03417	.000632	.03621
2.2	.03427	.000635	.03626	2.4	.03693	.000743	.03932
2.4	.03705	.000747	.03938	2.6	.03965	.000861	.04240
2.6	.03978	.000866	.04247	2.8	.04233	.000988	.04546
2.8	.04248	.000993	.04554	3.0	.04496	.001121	.04850
3.0	.04513	.001127	.04859	3.2	.04756	.001261	.05151
3.2	.04774	.001268	.05161	3.4	.05012	.001408	.05450
3.4	.05031	.001416	.05461	3.6	.05264	.001562	.05747
3.6	.05285	.001571	.05759	3.8	.05511	.001723	.06042
3.8	.05535	.001733	.06055	4.0	.05755	.001890	.06335
4.0	.05781	.001901	.06349	4.2	.05996	.002063	.06626
4.2	.06024	.002075	.06641	4.4	.06234	.002242	.06915
4.4	.06264	.002255	.06931	4.6	.06469	.002427	.07202

ϒ = 3.6				ϒ = 3.7			
φ	X	Y	T	φ	X	Y	T
4.6°	.13697	.006674	.10314	4.6°	.14235	.007040	.10480
4.4	.12439	.005683	.09650	4.4	.12820	.005925	.09775
4.2	.11361	.004872	.09035	4.2	.11645	.005041	.09133
4.0	.10410	.004190	.08457	4.0	.10627	.004311	.08536
3.8	.09554	.003606	.07909	3.8	.09723	.003695	.07973
3.6	.08772	.003101	.07386	3.6	.08906	.003166	.07437
3.4	.08050	.002659	.06883	3.4	.08157	.002708	.06925
3.2	.07378	.002272	.06398	3.2	.07463	.002308	.06432
3.0	.06748	.001931	.05928	3.0	.06816	.001957	.05956
2.8	.06154	.001630	.05472	2.8	.06208	.001649	.05495
2.6	.05592	.001364	.05029	2.6	.05635	.001378	.05047
2.4	.05056	.001130	.04596	2.4	.05090	.001140	.04611
2.2	.04545	.000925	.04173	2.2	.04572	.000932	.04185
2.0	.04056	.000745	.03760	2.0	.04076	.000750	.03769
1.8	.03586	.000590	.03354	1.8	.03602	.000593	.03362
1.6	.03134	.000455	.02957	1.6	.03145	.000457	.02962
1.4	.02698	.000341	.02567	1.4	.02706	.000342	.02571
1.2	.02276	.000245	.02183	1.2	.02282	.000246	.02186
1.0	.01868	.000167	.01806	1.0	.01872	.000167	.01808
0.8	.01473	.000105	.01434	0.8	.01476	.000105	.01435
0.6	.01089	.000058	.01068	0.6	.01091	.000058	.01069
0.4	.00716	.000025	.00707	0.4	.00717	.000025	.00708
+.2	.00354	.000006	.00351	+.2	.00354	.000006	.00351
0.0	.00000	.000000	.00000	0.0	.00000	.000000	.00000
−.2	.00345	.000006	.00347	−.2	.00345	.000006	.00347
0.4	.00681	.000024	.00690	0.4	.00681	.000024	.00690
0.6	.01010	.000052	.01028	0.6	.01009	.000052	.01028
0.8	.01332	.000092	.01363	0.8	.01330	.000091	.01363
1.0	.01646	.000141	.01695	1.0	.01644	.000140	.01694
1.2	.01954	.000200	.02023	1.2	.01951	.000199	.02021
1.4	.02256	.000269	.02347	1.4	.02252	.000268	.02346
1.6	.02552	.000346	.02669	1.6	.02546	.000345	.02666
1.8	.02842	.000432	.02987	1.8	.02835	.000431	.02984
2.0	.03127	.000527	.03303	2.0	.03119	.000525	.03299
2.2	.03407	.000629	.03615	2.2	.03397	.000627	.03611
2.4	.03682	.000740	.03925	2.4	.03670	.000737	.03920
2.6	.03952	.000858	.04233	2.6	.03939	.000854	.04226
2.8	.04218	.000983	.04538	2.8	.04203	.000978	.04530
3.0	.04479	.001116	.04840	3.0	.04463	.001110	.04832
3.2	.04737	.001255	.05140	3.2	.04719	.001249	.05131
3.4	.04991	.001401	.05438	3.4	.04971	.001394	.05428
3.6	.05241	.001554	.05734	3.6	.05219	.001546	.05723
3.8	.05487	.001713	.06028	3.8	.05463	.001704	.06016
4.0	.05729	.001878	.06320	4.0	.05704	.001868	.06306
4.2	.05968	.002049	.06610	4.2	.05941	.002038	.06594
4.4	.06204	.002226	.06898	4.4	.06175	.002214	.06881
4.6	.06437	.002409	.07184	4.6	.06406	.002396	.07166
4.8	.06667	.002598	.07468	4.8	.06634	.002583	.07449

γ = 3.8				γ = 3.9			
φ	X	Y	T	φ	X	Y	T
4.4°	.13261	.006209	.09915	4.4°	.13783	.006551	.10072
4.2	.11962	.005231	.09240	4.2	.12321	.005449	.09357
4.0	.10864	.004444	.08619	4.0	.11126	.004592	.08709
3.8	.09905	.003790	.08039	3.8	.10102	.003894	.08110
3.6	.09048	.003235	.07491	3.6	.09199	.003310	.07548
3.4	.08268	.002758	.06969	3.4	.08387	.002813	.07014
3.2	.07552	.002345	.06468	3.2	.07645	.002385	.06504
3.0	.06886	.001984	.05985	3.0	.06960	.002013	.06015
2.8	.06264	.001669	.05519	2.8	.06322	.001690	.05542
2.6	.05679	.001393	.05066	2.6	.05724	.001408	.05085
2.4	.05125	.001151	.04626	2.4	.05160	.001162	.04641
2.2	.04599	.000939	.04197	2.2	.04626	.000947	.04209
2.0	.04097	.000755	.03778	2.0	.04118	.000761	.03788
1.8	.03617	.000596	.03369	1.8	.03633	.000600	.03376
1.6	.03157	.000460	.02968	1.6	.03169	.000462	.02973
1.4	.02714	.000344	.02574	1.4	.02723	.000345	.02579
1.2	.02288	.000247	.02189	1.2	.02294	.000248	.02191
1.0	.01876	.000168	.01809	1.0	.01880	.000168	.01811
0.8	.01478	.000105	01436	0.8	.01480	.000105	.01438
0.6	.01092	.000058	.01069	0.6	.01093	.000058	.01070
0.4	.00718	.000025	.00708	0.4	.00718	.000025	.00708
+.2	.00354	.000006	.00351	+.2	.00354	.000006	.00352
0.0	.00000	.000000	.00000	0.0	.00000	.000000	.00000
−.2	.00345	.000006	.00347	−.2	.00344	.000006	.00347
0.4	.00681	.000024	.00689	0.4	.00680	.000024	.00689
0.6	.01008	.000052	.01028	0.6	.01007	.000052	.01027
0.8	.01329	.000092	.01362	0.8	.01327	.000091	.01361
1.0	.01641	.000141	.01693	1.0	.01639	.000140	.01691
1.2	.01948	.000199	.02020	1.2	.01944	.000198	.02017
1.4	.02247	.000267	.02343	1.4	.02242	.000266	.02340
1.6	.02541	.000344	.02663	1.6	.02535	.000342	.02660
1.8	.02828	.000430	.02980	1.8	.02821	.000427	.02976
2.0	.03111	.000523	.03294	2.0	.03102	.000521	.03289
2.2	.03388	.000625	.03605	2.2	.03377	.000622	.03600
2.4	.03660	.000734	.03913	2.4	.03648	.000730	.03907
2.6	.03927	.000850	.04219	2.6	.03913	.000846	.04212
2.8	.04189	.000974	.04522	2.8	.04175	.000969	.04514
3.0	.04448	.001105	.04823	3.0	.04431	.001099	.04814
3.2	.04702	.001242	.05121	3.2	.04683	.001235	.05111
3.4	.04952	.001386	.05417	3.4	.04931	.001378	.05406
3.6	.05198	.001537	.05711	3.6	.05176	.001528	.05699
3.8	.05440	.001694	.06002	3.8	.05417	.001684	.05989
4.0	.05678	.001857	.06291	4.0	.05654	.001846	.06277
4.2	.05913	.002026	.06578	4.2	.05888	.002014	.06563
4.4	.06145	.002200	.06864	4.4	.06118	.002187	.06847
4.6	.06374	.002380	.07148	4.6	.06345	.002366	.07130
4.8	.06600	.002566	.07430	4.8	.06569	.002550	.07411
5.0	.06824	.002757	.07710	5.0	.06790	.002739	.07690

γ = 4.0				γ = 4.1			
φ	X	Y	T	φ	X	Y	T
4.2°	.12735	.005704	.09487	4.2°	.13224	.006010	.09634
4.0	.11417	.004759	.08807	4.0	.11746	.004949	.08914
3.8	.10317	.004008	.08186	3.8	.10552	.004135	.08268
3.6	.09362	.003390	.07608	3.6	.09537	.003478	.07671
3.4	.08512	.002870	.07062	3.4	.08645	.002932	.07112
3.2	.07743	.002426	.06543	3.2	.07845	.002470	.06583
3.0	.07036	.002044	.06046	3.0	.07116	.002075	.06078
2.8	.06382	.001712	.05567	2.8	.06444	.001735	.05593
2.6	.05771	.001424	.05105	2.6	.05819	.001440	.05125
2.4	.05197	.001173	.04657	2.4	.05235	.001185	.04673
2.2	.04655	.000955	.04221	2.2	.04684	.000963	.04234
2.0	.04140	.000766	.03797	2.0	.04162	.000772	.03807
1.8	.03650	.000604	.03383	1.8	.03666	.000607	.03391
1.6	.03181	.000464	.02979	1.6	.03193	.000467	.02984
1.4	.02732	.000347	.02582	1.4	.02740	.000348	.02587
1.2	.02300	.000249	.02194	1.2	.02306	.000250	.02197
1.0	.01884	.000169	.01813	1.0	.01888	.000169	.01815
0.8	.01483	.000106	.01439	0.8	.01485	.000106	.01440
0.6	.01095	.000058	.01071	0.6	.01096	.000058	.01071
0.4	.00719	.000025	.00708	0.4	.00719	.000025	.00709
+.2	.00354	.000006	.00352	+.2	.00354	.000006	.00352
0.0	.00000	.000000	.00000	0.0	.00000	.000000	.00000
−.2	.00344	.000006	.00347	−.2	.00344	.000006	.00347
0.4	.00680	.000024	.00689	0.4	.00679	.000024	.00689
0.6	.01006	.000052	.01027	0.6	.01006	.000052	.01026
0.8	.01325	.000091	.01360	0.8	.01324	.000091	.01360
1.0	.01636	.000140	.01690	1.0	.01634	.000139	.01689
1.2	.01941	.000198	.02016	1.2	.01937	.000198	.02014
1.4	.02238	.000266	.02338	1.4	.02234	.000265	.02336
1.6	.02529	.000342	.02657	1.6	.02523	.000341	.02654
1.8	.02814	.000427	.02972	1.8	.02807	.000425	.02969
2.0	.03094	.000519	.03284	2.0	.03085	.000517	.03281
2.2	.03368	.000620	.03594	2.2	.03358	.000617	.03590
2.4	.03637	.000728	.03901	2.4	.03626	.000725	.03896
2.6	.03901	.000843	.04205	2.6	.03888	.000839	.04199
2.8	.04160	.000965	.04506	2.8	.04146	.000961	.04499
3.0	.04415	.001094	.04805	3.0	.04399	.001089	.04797
3.2	.04666	.001229	.05101	3.2	.04649	.001224	.05092
3.4	.04913	.001371	.05395	3.4	.04893	.001365	.05385
3.6	.05156	.001520	.05687	3.6	.05134	.001512	.05676
3.8	.05395	.001675	.05976	3.8	.05372	.001666	.05964
4.0	.05629	.001836	.06263	4.0	.05605	.001825	.06250
4.2	.05860	.002002	.06548	4.2	.05835	.001990	.06534
4.4	.06088	.002174	.06831	4.4	.06062	.002160	.06816
4.6	.06313	.002351	.07112	4.6	.06286	.002336	.07096
4.8	.06536	.002534	.07392	4.8	.06506	.002517	.07374
5.0	.06756	.002722	.07670	5.0	.06723	.002704	.07651
5.2	.06973	.002915	.07946	5.2	.06938	.002896	.07926

γ = 4.2				γ = 4.3			
φ	X	Y	T	φ	X	Y	T
4.0°	.12122	.005169	.09032	4.0°	.12561	.005431	.09165
3.8	.10813	.004276	.08355	3.8	.11103	.004435	.08450
3.6	.09726	.003573	.07738	3.6	.09932	.003677	.07810
3.4	.08787	.002998	.07165	3.4	.08938	.003069	.07220
3.2	.07953	.002517	.06624	3.2	.08067	.002566	.06667
3.0	.07199	.002109	.06110	3.0	.07286	.002143	.06144
2.8	.06509	.001759	.05619	2.8	.06575	.001783	.05646
2.6	.05870	.001457	.05146	2.6	.05921	.001474	.05167
2.4	.05273	.001197	.04689	2.4	.05312	.001209	.04706
2.2	.04713	.000972	.04247	2.2	.04743	.000980	.04260
2.0	.04185	.000778	.03817	2.0	.04207	.000783	.03827
1.8	.03683	.000611	.03398	1.8	.03700	.000615	.03406
1.6	.03205	.000469	.02990	1.6	.03218	.000472	.02996
1.4	.02749	.000350	.02591	1.4	.02758	.000351	.02595
1.2	.02312	.000251	.02200	1.2	.02318	.000251	.02203
1.0	.01892	.000170	.01817	1.0	.01896	.000170	.01819
0.8	.01487	.000106	.01441	0.8	.01490	.000106	.01442
0.6	.01097	.000059	.01072	0.6	.01098	.000059	.01072
0.4	.00720	.000026	.00709	0.4	.00720	.000025	.00709
+.2	.00354	.000006	.00352	+.2	.00354	.000006	.00352
0.0	.00000	.000000	.00000	0.0	.00000	.000000	.00000
−.2	.00344	.000006	.00347	−.2	.00344	.000006	.00347
0.4	.00679	.000024	.00689	0.4	.00678	.000023	.00688
0.6	.01004	.000052	.01026	0.6	.01004	.000052	.01025
0.8	.01322	.000091	.01359	0.8	.01320	.000090	.01358
1.0	.01631	.000139	.01687	1.0	.01629	.000139	.01686
1.2	.01934	.000197	.02012	1.2	.01930	.000197	.02010
1.4	.02229	.000264	.02333	1.4	.02225	.000263	.02331
1.6	.02518	.000340	.02651	1.6	.02512	.000339	.02648
1.8	.02800	.000424	.02965	1.8	.02794	.000422	.02961
2.0	.03077	.000516	.03276	2.0	.03070	.000514	.03271
2.2	.03348	.000615	.03584	2.2	.03339	.000612	.03579
2.4	.03614	.000722	.03889	2.4	.03604	.000719	.03883
2.6	.03875	.000836	.04192	2.6	.03863	.000832	.04184
2.8	.04132	.000957	.04491	2.8	.04118	.000952	.04483
3.0	.04384	.001085	.04788	3.0	.04368	.001079	.04779
3.2	.04631	.001219	.05082	3.2	.04614	.001212	.05072
3.4	.04874	.001359	.05374	3.4	.04856	.001351	.05363
3.6	.05114	.001505	.05664	3.6	.05094	.001497	.05652
3.8	.05349	.001658	.05951	3.8	.05328	.001648	.05938
4.0	.05581	.001816	.06236	4.0	.05558	.001805	.06222
4.2	.05809	.001979	.06519	4.2	.05784	.001967	.06504
4.4	.06034	.002148	.06800	4.4	.06007	.002135	.06784
4.6	.06256	.002322	.07079	4.6	.06227	.002308	.07062
4.8	.06475	.002502	.07356	4.8	.06444	.002486	.07338
5.0	.06691	.002687	.07632	5.0	.06658	.002670	.07612
5.2	.06904	.002877	.07906	5.2	.06869	.002859	.07885
5.4	.07114	.003072	.08178	5.4	.07077	.003052	.08156

$\gamma = 4.4$				$\gamma = 4.5$			
φ	X	Y	T	φ	X	Y	T
3.8°	.11434	.004621	.08554	3.8°	.11816	.004833	.08671
3.6	.10159	.003794	.07886	3.6	.10409	.003923	.07969
3.4	.09102	.003147	.07278	3.4	.09278	.003230	.07340
3.2	.08188	.002620	.06712	3.2	.08317	.002676	.06760
3.0	.07378	.002180	.06180	3.0	.07474	.002219	.06216
2.8	.06645	.001809	.05673	2.8	.06718	.001836	.05702
2.6	.05974	.001493	.05189	2.6	.06030	.001511	.05212
2.4	.05354	.001222	.04723	2.4	.05396	.001234	.04741
2.2	.04775	.000989	.04273	2.2	.04807	.000998	.04287
2.0	.04231	.000789	.03837	2.0	.04255	.000795	.03848
1.8	.03718	.000619	.03414	1.8	.03736	.000623	.03422
1.6	.03231	.000474	.03001	1.6	.03244	.000477	.03007
1.4	.02767	.000353	.02599	1.4	.02777	.000354	.02603
1.2	.02324	.000252	.02206	1.2	.02331	.000253	.02209
1.0	.01900	.000171	.01821	1.0	.01904	.000171	.01823
0.8	.01492	.000107	.01443	0.8	.01495	.000107	.01445
0.6	.01100	.000059	.01073	0.6	.01101	.000059	.01074
0.4	.00721	.000025	.00709	0.4	.00721	.000026	.00710
+.2	.00355	.000006	.00352	+.2	.00355	.000006	.00352
0.0	.00000	.000000	.00000	0.0	.00000	.000000	.00000
−.2	.00344	.000006	.00347	−.2	.00344	.000006	.00346
0.4	.00678	.000024	.00688	0.4	.00678	.000023	.00688
0.6	.01002	.000052	.01025	0.6	.01002	.000052	.01024
0.8	.01318	.000090	.01357	0.8	.01317	.000090	.01356
1.0	.01626	.000139	.01685	1.0	.01624	.000138	.01683
1.2	.01927	.000197	.02009	1.2	.01924	.000196	.02007
1.4	.02220	.000263	.02329	1.4	.02216	.000262	.02326
1.6	.02507	.000338	.02645	1.6	.02501	.000337	.02642
1.8	.02787	.000421	.02958	1.8	.02781	.000420	.02954
2.0	.03061	.000512	.03268	2.0	.03054	.000510	.03263
2.2	.03330	.000611	.03574	2.2	.03321	.000608	.03569
2.4	.03593	.000717	.03878	2.4	.03583	.000713	.03872
2.6	.03851	.000830	.04178	2.6	.03839	.000825	.04171
2.8	.04105	.000949	.04476	2.8	.04091	.000944	.04468
3.0	.04353	.001075	.04771	3.0	.04338	.001069	.04762
3.2	.04598	.001207	.05063	3.2	.04581	.001201	.05054
3.4	.04838	.001346	.05353	3.4	.04820	.001338	.05343
3.6	.05074	.001490	.05641	3.6	.05054	.001482	.05630
3.8	.05306	.001640	.05926	3.8	.05285	.001631	.05914
4.0	.05535	.001796	.06209	4.0	.05512	.001785	.06196
4.2	.05760	.001957	.06490	4.2	.05735	.001945	.06476
4.4	.05982	.002123	.06769	4.4	.05955	.002110	.06754
4.6	.06200	.002295	.07046	4.6	.06172	.002281	.07030
4.8	.06415	.002472	.07321	4.8	.06386	.002457	.07304
5.0	.06627	.002654	.07594	5.0	.06596	.002638	.07576
5.2	.06836	.002840	.07865	5.2	.06804	.002824	.07846
5.4	.07043	.003031	.08134	5.4	.07009	.003014	.08114
5.6	.07247	.003227	.08402	5.6	.07211	.003208	.08381

γ = 4.6				γ = 4.7			
φ	X	Y	T	φ	X	Y	T
3.8°	.12268	.005092	.08803	3.6°	.11009	.004240	.08158
3.6	.10690	.004070	.08060	3.4	.09679	.003425	.07476
3.4	.09470	.003323	.07406	3.2	.08601	.002803	.06862
3.2	.08454	.002737	.06810	3.0	.07682	.002304	.06295
3.0	.07575	.002260	.06255	2.8	.06873	.001894	.05763
2.8	.06794	.001864	.05732	2.6	.06146	.001551	.05258
2.6	.06087	.001531	.05235	2.4	.05483	.001262	.04777
2.4	.05439	.001248	.04759	2.2	.04872	.001017	.04315
2.2	.04839	.001007	.04301	2.0	.04304	.000808	.03869
2.0	.04280	.000802	.03858	1.8	.03772	.000631	.03438
1.8	.03754	.000627	.03430	1.6	.03270	.000482	.03019
1.6	.03257	.000480	.03013	1.4	.02795	.000358	.02612
1.4	.02786	.000356	.02607	1.2	.02343	.000255	.02215
1.2	.02337	.000254	.02212	1.0	.01912	.000172	.01827
1.0	.01908	.000172	.01825	0.8	.01499	.000108	.01447
0.8	.01497	.000107	.01446	0.6	.01103	.000059	.01075
0.6	.01102	.000059	.01075	0.4	.00722	.000026	.00710
0.4	.00722	.000026	.00710	+.2	.00355	.000006	.00352
+.2	.00355	.000006	.00352	0.0	.00000	.000000	.00000
0.0	.00000	.000000	.00000	−.2	.00344	.000006	.00346
−.2	.00344	.000006	.00346	0.4	.00677	.000023	.00687
0.4	.00677	.000023	.00688	0.6	.01000	.000052	.01023
0.6	.01001	.000052	.01024	0.8	.01314	.000090	.01354
0.8	.01315	.000090	.01355	1.0	.01619	.000138	.01681
1.0	.01622	.000138	.01682	1.2	.01917	.000195	.02004
1.2	.01920	.000196	.02005	1.4	.02207	.000261	.02322
1.4	.02212	.000262	.02324	1.6	.02490	.000335	.02636
1.6	.02496	.000336	.02639	1.8	.02767	.000417	.02947
1.8	.02774	.000419	.02951	2.0	.03038	.000507	.03255
2.0	.03046	.000509	.03259	2.2	.03303	.000604	.03559
2.2	.03312	.000606	.03564	2.4	.03562	.000708	.03860
2.4	.03572	.000711	.03866	2.6	.03816	.000819	.04158
2.6	.03828	.000823	.04164	2.8	.04065	.000936	.04453
2.8	.04078	.000941	.04460	3.0	.04309	.001060	.04745
3.0	.04324	.001065	.04754	3.2	.04549	.001189	.05035
3.2	.04565	.001196	.05044	3.4	.04784	.001325	.05322
3.4	.04802	.001332	.05332	3.6	.05016	.001467	.05607
3.6	.05035	.001475	.05618	3.8	.05243	.001614	.05890
3.8	.05264	.001623	.05901	4.0	.05467	.001766	.06170
4.0	.05490	.001777	.06182	4.2	.05687	.001923	.06448
4.2	.05712	.001936	.06461	4.4	.05904	.002086	.06724
4.4	.05931	.002100	.06738	4.6	.06117	.002254	.06998
4.6	.06146	.002269	.07013	4.8	.06327	.002427	.07270
4.8	.06357	.002443	.07286	5.0	.06534	.002606	.07539
5.0	.06565	.002621	.07557	5.2	.06738	.002789	.07807
5.2	.06771	.002804	.07826	5.4	.06939	.002976	.08073
5.4	.06974	.002992	.08093	5.6	.07138	.003167	.08338
5.6	.07174	.003185	.08359	5.8	.07334	.003362	.08601

$\gamma = 4.8$				$\gamma = 4.9$			
φ	X	Y	T	φ	X	Y	T
3.6^{0}	.11380	.004438	.08269	3.6^{0}	.11823	.004679	.08395
3.4	.09911	.003539	.07552	3.4	.10171	.003667	.07635
3.2	.08760	.002874	.06917	3.2	.08932	.002951	.06977
3.0	.07795	.002351	.06336	3.0	.07915	.002400	.06380
2.8	.06955	.001925	.05794	2.8	.07043	.001958	.05828
2.6	.06207	.001572	.05282	2.6	.06272	.001595	.05308
2.4	.05529	.001276	.04796	2.4	.05577	.001291	.04816
2.2	.04907	.001026	.04329	2.2	.04942	.001036	.04344
2.0	.04330	.000814	.03880	2.0	.04356	.000821	.03892
1.8	.03791	.000635	.03446	1.8	.03810	.000640	.03455
1.6	.03284	.000485	.03025	1.6	.03297	.000487	.03032
1.4	.02805	.000359	.02616	1.4	.02814	.000361	.02621
1.2	.02350	.000256	.02217	1.2	.02356	.000257	.02221
1.0	.01916	.000173	.01828	1.0	.01921	.000173	.01831
0.8	.01502	.000108	.01448	0.8	.01505	.000108	.01449
0.6	.01105	.000059	.01076	0.6	.01106	.000059	.01076
0.4	.00723	.000026	.00710	0.4	.00724	.000026	.00711
+.2	.00355	.000006	.00352	+.2	.00355	.000006	.00352
0.0	.00000	.000000	.00000	0.0	.00000	.000000	.00000
−.2	.00343	.000006	.00346	−.2	.00343	.000006	.00346
0.4	.00676	.000023	.00687	0.4	.00676	.000023	.00687
0.6	.00999	.000051	.01023	0.6	.00998	.000051	.01022
0.8	.01312	.000090	.01353	0.8	.01311	.000090	.01353
1.0	.01617	.000138	.01679	1.0	.01615	.000137	.01679
1.2	.01913	.000195	.02001	1.2	.01910	.000194	.02000
1.4	.02203	.000260	.02319	1.4	.02199	.000260	.02317
1.6	.02485	.000334	.02633	1.6	.02480	.000333	.02631
1.8	.02761	.000416	.02943	1.8	.02754	.000415	.02940
2.0	.03030	.000506	.03250	2.0	.03022	.000504	.03247
2.2	.03293	.000602	.03554	2.2	.03285	.000600	.03549
2.4	.03551	.000706	.03854	2.4	.03541	.000703	.03849
2.6	.03804	.000816	.04151	2.6	.03792	.000813	.04145
2.8	.04052	.000933	.04446	2.8	.04039	.000929	.04439
3.0	.04294	.001056	.04737	3.0	.04280	.001051	.04730
3.2	.04533	.001185	.05026	3.2	.04517	.001179	·05018
3.4	.04767	.001320	.05312	3.4	.04749	.001313	.05303
3.6	.04997	.001460	.05596	3.6	.04978	.001453	.05586
3.8	.05223	.001607	.05877	3.8	.05202	.001598	.05867
4.0	.05445	.001758	.06157	4.0	.05423	.001748	.06145
4.2	.05663	.001914	.06434	4.2	.05640	.001903	.06421
4.4	.05878	.002075	.06709	4.4	.05854	.002063	.06695
4.6	.06090	.002242	.06982	4.6	.06064	.002228	.06967
4.8	.06299	.002414	.07253	4.8	.06271	.002399	.07237
5.0	.06504	.002590	.07521	5.0	.06475	.002575	.07504
5.2	.06707	.002771	.07788	5.2	.06676	.002755	.07770
5.4	.06907	.002957	.08053	5.4	.06874	.002939	.08034
5.6	.07104	.003147	.08316	5.6	.07070	.003127	.08296
5.8	.07298	.003341	.08578	5.8	.07263	.003319	.08557

$\gamma = 5.0$				$\gamma = 5.0$			
φ	X	Y	T	φ	X	Y	T
3.4°	.10465	.003815	.07725	1.4°	.02194	.000259	.02315
3.2	.09119	.003038	.07039	1.6	.02474	.000332	.02628
3.0	.08044	.002455	.06425	1.8	.02748	.000414	.02937
2.8	.07134	.001993	.05861	2.0	.03015	.000502	.03242
2.6	.06338	.001618	.05334	2.2	.03276	.000598	.03544
2.4	.05626	.001306	.04834	2.4	.03531	.000700	.03843
2.2	.04978	.001046	.04359	2.6	.03781	.000809	.04139
2.0	.04383	.000828	.03902	2.8	.04026	.000925	.04431
1.8	.03829	.000644	.03463	3.0	.04266	.001046	.04721
1.6	.03311	.000490	.03037	3.2	.04501	.001174	.05008
1.4	.02824	.000362	.02625	3.4	.04732	.001307	.05293
1.2	.02363	.000258	.02224	3.6	.04959	.001446	.05575
1.0	.01925	.000174	.01832	3.8	.05182	.001590	.05854
0.8	.01507	.000108	.01451	4.0	.05401	.001740	.06131
0.6	.01108	.000059	.01077	4.2	.05616	.001895	.06406
0.4	.00724	.000026	.00711	4.4	.05828	.002054	.06679
+.2	.00355	.000006	.00352	4.6	.06037	.002218	.06950
0.0	.00000	.000000	.00000	4.8	.06243	.002387	.07219
−.2	.00343	.000006	.00346	5.0	.06446	.002560	.07486
0.4	.00675	.000023	.00687	5.2	.06646	.002738	.07751
0.6	.00997	.000051	.01022	5.4	.06843	.002920	.08014
0.8	.01309	.000089	.01352	5.6	.07037	.003107	.08275
1.0	.01612	.000137	.01677	5.8	.07228	.003298	.08535
1.2	.01907	.000194	.01998	6.0	.07416	.003493	.08793

V. $P_\varphi = 3 \tan \varphi + \tan^3 \varphi$.

φ	.0	.2	.4	.6	.8
0°	000 000	.010 472	.020 945	.031 418	.041 893
1	.052 371	.062 850	.073 333	.083 819	.094 310
2	.104 805	.115 305	.125 811	.136 323	.146 842
3	.157 367	.167 901	.178 442	.188 993	.199 553
4	.210 122	.220 702	.231 293	.241 895	.252 509
5	.263 136	.273 775	.284 428	.295 095	.305 777
6	.316 474	.327 186	.337 915	.348 661	.359 424
7	.370 205	.381 004	.391 823	.402 661	.413 519
8	.424 398	.435 299	.446 222	.457 167	.468 135
9	.479 126	.490 143	.501 184	.512 251	.523 344
10	.534 463	.545 610	.556 785	.567 989	.579 222
11	.590 485	.601 779	.613 104	.624 461	.635 850
12	.647 273	.658 730	.670 221	.681 748	.693 310
13	.704 910	.716 547	.728 222	.739 936	.751 690

$$P_\varphi = 3 \tan \varphi + \tan^3 \varphi.$$

φ	.0	.2	.4	.6	.8
14°	.763 483	.775 319	.787 196	.799 115	.811 078
15	.823 086	.835 138	.847 236	.859 381	.871 573
16	.883 813	.896 103	.908 442	.920 832	.933 275
17	.945 769	.958 317	.970 919	.983 577	.996 291
18	1.009 062	1.021 891	1.034 779	1.047 727	1.060 736
19	1.073 807	1.086 941	1.100 139	1.113 402	1.126 731
20	1.140 127	1.153 592	1.167 126	1.180 730	1.194 407
21	1.208 155	1.221 978	1.235 875	1.249 849	1.263 901
22	1.278 031	1.292 241	1.306 532	1.320 906	1.335 363
23	1.349 906	1.364 535	1.379 252	1.394 058	1.408 955
24	1.423 943	1.439 025	1.454 202	1.469 476	1.484 847
25	1.500 318	1.515 890	1.531 565	1.547 344	1.563 229
26	1.579 221	1.595 323	1.611 535	1.627 861	1.644 301
27	1.660 857	1.677 532	1.694 327	1.711 244	1.728 284
28	1.745 450	1.762 745	1.780 169	1.797 726	1.815 417
29	1.833 244	1.851 209	1.869 315	1.887 564	1.905 959
30	1.924 501	1.943 193	1.962 038	1.981 038	2.000 195
31	2.019 513	2.038 993	2.058 639	2.078 452	2.098 437
32	2.118 596	2.138 931	2.159 446	2.180 143	2.201 026
33	2.222 098	2.243 361	2.264 820	2.286 477	2.308 337
34	2.330 401	2.352 674	2.375 160	2.397 862	2.420 783
35	2.443 928	2.467 300	2.490 904	2.514 743	2.538 821
36	2.563 143	2.587 714	2.612 536	2.637 615	2.662 957
37	2.688 563	2.714 441	2.740 594	2.767 029	2.793 748
38	2.820 759	2.848 066	2.875 675	2.903 591	2.931 820
39	2.960 368	2.989 240	3.018 444	3.047 983	3.077 866
40	3.108 099	3.138 688	3.169 640	3.200 962	3.232 661
41	3.264 745	3.297 220	3.330 095	3.363 377	3.397 074
42	3.431 194	3.465 746	3.500 739	3.536 180	3.572 079
43	3.608 446	3.645 289	3.682 618	3.720 444	3.758 776
44	3.797 624	3.837 000	3.876 914	3.917 378	3.958 402
45	4.000 000	4.042 183	4.084 962	4.128 352	4.172 365
46	4.217 014	4.262 314	4.308 277	4.354 920	4.402 257
47	4.450 304	4.499 074	4.548 585	4.598 854	4.649 898
48	4.701 734	4.754 380	4.807 854	4.862 177	4.917 366
49	4.973 442	5.030 427	5.088 340	5.147 206	5.207 045
50	5.267 881	5.329 737	5.392 639	5.456 611	5.521 681
51	5.587 874	5.655 218	5.723 742	5.793 475	5.864 448
52	5.936 691	6.010 238	6.085 117	6.161 368	6.239 026
53	6.318 124	6.398 702	6.480 797	6.564 452	6.649 706
54	6.736 602	6.825 183	6.915 496	7.007 588	7.101 509
55	7.197 304	7.295 031	7.394 739	7.496 488	7.600 333
56	7.706 333	7.814 550	7.925 047	8.037 894	8.153 153
57	8.270 898	8.391 203	8.514 142	8.639 795	8.768 244
58	8.899 574	9.033 869	9.171 225	9.311 731	9.455 492
59	9.602 605	9.753 175	9.907 314	10.065 136	10.226 756

VI. VALUES OF X, Y & T FOR INTERVALS OF 1°.

γ = 0.00

φ	X	Y	T
60°	1.73205	1.50000	1.73205
59	1.66428	1.38492	1.66428
58	1.60033	1.28054	1.60033
57	1.53986	1.18559	1.53986
56	1.48256	1.09899	1.48256
55	1.42815	1.01980	1.42815
54	1.37638	.947215	1.37638
53	1.32704	.880524	1.32704
52	1.27994	.819125	1.27994
51	1.23490	.762486	1.23490
50	1.19175	.710138	1.19175
49	1.15037	.661674	1.15037
48	1.11061	.616730	1.11061
47	1.07237	.574987	1.07237
46	1.03553	.536162	1.03553
45	1.00000	.500000	1.00000
44	.96569	.466278	.96569
43	.93252	.434792	.93252
42	.90040	.405363	.90040
41	.86929	.377830	.86929
40	.83910	.352044	.83910
39	.80978	.327875	.80978
38	.78129	.305204	.78129
37	.75355	.283922	.75355
36	.72654	.263932	.72654
35	.70021	.245145	.70021
34	.67451	.227481	.67451
33	.64941	.210865	.64941
32	.62487	.195231	.62487
31	.60086	.180517	.60086
30	.57735	.166667	.57735
29	.55431	.153629	.55431
28	.53171	.141358	.53171
27	.50953	.129808	.50953
26	.48773	.118942	.48773
25	.46631	.108721	.46631
24	.44523	.099114	.44523
23	.42448	.090090	.42448
22	.40403	.081619	.40403
21	.38386	.073676	.38386
20	.36397	.066237	.36397
19	.34433	.059281	.34433
18°	.32492	.052786	.32492
17	.30573	.046736	.30573
16	.28675	.041112	.28675
15	.26795	.035898	.26795
14	.24933	.031082	.24933
13	.23087	.026650	.23087
12	.21256	.022590	.21256
11	.19438	.018892	.19438
10	.17633	.015546	.17633
9	.15838	.012543	.15838
8	.14054	.009876	.14054
7	.12279	.007538	.12279
6	.10510	.005524	.10510
5	.08749	.003827	.08749
4	.06993	.002445	.06993
3	.05241	.001373	.05241
2	.03492	.000610	.03492
+1	.01746	.000152	.01746
0	00000	000000	00000

γ = 0.01

φ	X	Y	T
60°	1.77949	1.55885	1.75552
59	1.70679	1.43539	1.68533
58	1.63857	1.32404	1.61928
57	1.57437	1.22324	1.55697
56	1.51380	1.13170	1.49806
55	1.45651	1.04831	1.44222
54	1.40219	.97214	1.38919
53	1.35058	.90238	1.33873
52	1.30144	.83834	1.29063
51	1.25458	.77941	1.24468
50	1.20980	.72508	1.20073
49	1.16694	.67488	1.15861
48	1.12585	.62843	1.11820
47	1.08640	.58536	1.07935
46	1.04847	.54537	1.04196
45	1.01192	.50818	1.00593
44	.97669	.47355	.97116
53	.94267	.44127	.93757

γ = 0.01				γ = 0,01			
φ	X	Y	T	φ	X	Y	T
42°	.90978	.41114	.90507	4°	.06988	.002443	.06990
41	.87795	.38297	.87361	5	.08741	.003823	.08745
40	.84710	.35662	.84309	6	.10499	.005516	.10505
39	.81718	.33195	.81347	7	.12264	.007525	.12271
38	.78812	.30883	.78469	8	.14034	.009857	.14044
37	.75986	.28715	.75670	9	.15813	.012516	.15826
36	.73237	.26681	.72944	10	.17602	.015509	.17618
35	.70559	.24769	.70290	11	.19400	.018843	.19420
34	.67947	.22974	.67698	12	.21211	.022526	.21234
33	.65398	.21287	.65169	13	.23034	.026568	.23060
32	.62908	.19701	.62697	14	.24870	.030978	.24902
31	.60473	.18209	.60279	15	.26723	.035769	.26759
30	.58091	.168051	.57913	16	.28592	.040952	.28633
29	.55758	.154847	.55594	17	.30479	.046543	.30526
28	.53470	.142427	.53320	18	.32385	.052554	.32439
27	.51226	.130745	.51089	19	.34313	.059005	.34373
26	.49023	.119760	.48898	20	.36262	.065909	.36330
25	.46859	.109433	.46744	21	.38236	.073290	.38311
24	.44729	.099732	.44626	22	.40236	.081168	.40319
23	.42635	.090623	.42541	23	.42263	.089565	.42355
22	.40572	.082077	.40487	24	.44320	.098508	.44421
21	.38539	.074067	.38462	25	.46407	.108022	.46519
20	.36534	.066569	.36465	26	.48528	.118139	.48650
19	.34555	.059561	.34494	27	.50684	.128889	.50818
18	.32601	.053021	.32546	28	.52878	.140309	.53024
17	.30669	.046931	.30621	29	.55111	.152437	.55270
16	.28758	.041272	.28717	30	.57387	.165314	.57560
15	.26868	.036029	.26831	31	.59707	.178985	.59896
14	.24996	.031187	.24964	32	.62075	.193499	.62281
13	.23141	.026734	.23114	33	.64494	.208911	.64717
12	.21302	.022655	.21279	34	.66967	.225279	.67208
11	.19476	.018941	.19457	35	.69497	.242668	.69758
10	.17664	.015583	.17649	36	.72087	.261147	.72370
9	.15863	.012570	.15850	37	.74742	.280795	.75048
8	.14074	.009894	.14064	38	.77465	.301694	.77796
7	.12294	.007550	.12286	39	.80262	.323939	.80619
6	.10521	.005531	.10516	40	.83135	.347631	.83521
5	.08757	.003832	.08752	41	.86092	.372884	.86509
4	.06998	.002447	.06995	42	.89136	.399820	.89586
3	.05244	.001374	.05242	43	.92274	.428576	.92761
2	.03493	.000610	.03493	44	.95512	.459307	.96038
+ 1	.01746	.000152	.01746	45	.98856	.492182	.99426
	+	+	+	46	1.02315	.527388	1.02931
0	00000	000000	00000	47	1.05896	.565132	1.06564
°	—	+	—	48	1.09608	.605648	1.10331
− 1	.01745	.000152	.01745	49	1.13461	.649198	1.14245
2	.03490	.000610	.03491	50	1.17464	.696076	1.18315
3	.05238	.001373	.05239	51	1.21629	.746612	1.22554

$\gamma = 0.01$

φ	X	Y	T
52°	1.25968	.801177	1.26976
53	1.30496	.860189	1.31593
54	1.35226	.924126	1.36424
55	1.40176	.993530	1.41486
56	1.45363	1.069017	1.46799
57	1.50807	1.151292	1.52384
58	1.56531	1.241166	1.58267
59	1.62559	1.339565	1.64476
60	1.68919	1.447563	1.71042

$\gamma = 0.02$

φ	X	Y	T
60°	1.83254	1.62567	1.78117
59	1.75391	1.49213	1.70817
58	1.68062	1.37250	1.63971
57	1.61206	1.26485	1.57533
56	1.54771	1.16759	1.51460
55	1.48712	1.07941	1.45718
54	1.42990	.99918	1.40276
53	1.37575	.92598	1.35107
52	1.32435	.85898	1.30187
51	1.27548	.79753	1.25494
50	1.22890	.74101	1.21012
49	1.18443	.68892	1.16721
48	1.14188	.64082	1.12609
47	1.10111	.59632	1.08660
46	1.06198	.55508	1.04863
45	1.02436	.51679	1.01207
44	.98814	.48119	.97682
43	.95322	.44805	.94278
42	.91950	.41716	.90988
41	.88692	.38832	.87804
40	.85537	.36138	.84718
39	.82481	.33618	.81725
38	.79516	.31259	.78818
37	.76636	.29049	.75992
36	.73836	.26977	.73241
35	.71111	.25032	.70563
34	.68455	.23207	.67950
33	.65866	.21493	.65401
32	.63339	.19883	.62911
31	.60869	.18370	.60476
30	.58454	.169469	.58093
29	.56091	.156094	.55759
28	.53775	.143521	.53471
27°	.51505	.131702	.51227
26	.49277	.120594	.49024
25	.47090	.110159	.46859
24	.44939	.100361	.44730
23	.42825	.091165	.42635
22	.40743	.082542	.40572
21	.38693	.074464	.38539
20	.36672	.066906	.36534
19	.34678	.059845	.34555
18	.32710	.053259	.32600
17	.30765	.047128	.30669
16	.28843	.041434	.28759
15	.26942	.036161	.26868
14	.25060	.031293	.24996
13	.23196	.026818	.23141
12	.21348	.022720	.21302
11	.19515	.018991	.19476
10	.17696	.015620	.17665
9	.15889	.012597	.15863
8	.14094	.009913	.14074
7	.12309	.007563	.12294
6	.10532	.005539	.10521
5	.08765	.003836	.08756
4	.07003	.002450	.06998
3	.05247	.001376	.05244
2	.03494	.000611	.03493
+1	.01746	.000153	.01746
	+	+	+
0	00000	000000	00000
	—	+	—
−1°	.01745	.000152	.01745
2	.03489	.000610	.03491
3	.05235	.001372	.05238
4	.06983	.002440	.06988
5	.08734	.003818	.08741
6	.10488	.005508	.10499
7	.12249	.007513	.12264
8	.14015	.009839	.14034
9	.15788	.012490	.15813
10	.17571	.015473	.17602
11	.19362	.018794	.19401
12	.21166	.022462	.21211
13	.22981	.026486	.23034
14	.24808	.030875	.24871
15	.26651	.035641	.26723
16	.28510	.040795	.28592
17	.30385	.046352	.30479
18	.32279	.052324	.32386

$\gamma = 0.02$				$\gamma = 0.03$			
φ	X	Y	T	φ	X	Y	T
19°	.34194	.058732	.34314	60°	1.89266	1.70264	1.80950
20	.36129	.065586	.36263	59	1.80671	1.55667	1.73318
21	.38088	.072911	.38237	58	1.72729	1.42703	1.66191
22	.40072	.080724	.40237	57	1.65355	1.31123	1.59513
23	.42082	.089050	.42264	56	1.58476	1.20728	1.53235
24	.44119	.097912	.44320	55	1.52035	1.11354	1.47315
25	.46187	.107336	.46408	54	1.45983	1.02867	1.41718
26	.48287	.117351	.48529	53	1.40278	.95155	1.36413
27	.50420	.127989	.50685	52	1.34885	.88125	1.31372
28	.52590	.139284	.52879	51	1.29773	.81697	1.26574
29	.54797	.151271	.55113	50	1.24916	.75803	1.21996
30	.57045	.163992	.57389	49	1.20291	.70387	1.17621
31	.59336	.177489	.59710	48	1.15877	.65397	1.13432
32	.61673	.191811	.62078	47	1.11657	.60792	1.09414
33	.64058	.207008	.64497	46	1.07614	.56532	1.05555
34	.66495	.223138	.66971	45	1.03735	.52585	1.01843
35	.68986	.240262	.69501	44	1.00008	.48921	.98267
36	.71535	.258446	.72092	43	.96419	.45514	.94817
37	.74146	.277765	.74747	42	.92960	.42344	.91484
38	.76822	.298300	.77471	41	.89621	.39389	.88260
39	.79567	.320137	.80268	40	.86393	.36632	.85139
40	.82385	.343375	.83143	39	.83269	.34057	.82113
41	.85282	.368121	.86100	38	.80242	.31648	.79175
42	.88262	.394495	.89145	37	.77305	.29395	.76321
43	.91331	.422624	.92284	36	.74452	.27283	.73545
44	.94494	.452645	.95523	35	.71678	.25304	.70842
45	.97758	.484721	.98870	34	.68977	.23447	.68208
46	1.01129	.519028	1.02330	33	.66346	.21705	.65638
47	1.04614	.555761	1.05914	32	.63780	.20070	.63128
48	1.08221	.595136	1.09628	31	.61274	.18535	.60676
49	1.11960	.637396	1.13483	30	.58825	.170923	.58277
50	1.15838	.682811	1.17489	29	.56430	.157371	.55927
51	1.19866	.731683	1.21658	28	.54085	.144639	.53625
52	1.24054	.784351	1.26002	27	.51788	.132679	.51367
53	1.28415	.841196	1.30534	26	.49535	.121445	.49152
54	1.32961	.902648	1.35270	25	.47324	.110898	.46976
55	1.37707	.969193	1.40226	24	.45152	.101000	.44836
56	1.42667	1.041380	1.45421	23	.43017	.091716	.42731
57	1.47859	1.119831	1.50875	22	.40917	.083014	.40659
58	1.53299	1.205257	1.56611	21	.38849	.074867	.38617
59	1.59010	1.298469	1.62654	20	.36811	.067249	.36603
60	1.65012	1.400388	1.69032	19	.34802	.060134	.34617
				18	.32820	.053501	.32655
				17	.30863	.047329	.30717
				16	.28928	.041599	.28801
				15	.27016	.036295	.26905
				14	.25124	.031401	.25028
				13	.23251	.026903	.23168

γ = 0,03

φ	X	Y	T
12°	.21394	.022786	.21325
11	.19553	.019041	.19496
10	.17727	.015657	.17681
9	.15914	.012624	.15876
8	.14114	.009932	.14084
7	.12324	.007575	.12301
6	.10543	.005547	.10527
5	.08772	.003841	.08760
4	.07008	.002452	.07000
3	.05249	.001376	.05245
2	.03496	.000611	.03494
+1	.01747	.000152	.01746
	+	+	+
0	00000	000000	00000
	—	+	—
−1°	.01745	.000152	.01745
2	.03488	.000609	.03490
3	.05232	.001371	.05237
4	.06978	.002438	.06985
5	.08726	.003814	.08738
6	.10477	.005501	.10494
7	.12233	.007501	.12256
8	.13995	.009820	.14025
9	.15763	.012463	.15801
10	.17540	.015437	.17587
11	.19325	.018746	.19382
12	.21121	.022399	.21189
13	.22928	.026405	.23007
14	.24747	.030773	.24840
15	.26580	.035514	.26687
16	.28428	.040640	.28551
17	.30292	.046163	.30432
18	.32174	.052098	.32333
19	.34076	.058462	.34255
20	.35998	.065267	.36197
21	.37942	.072536	.38163
22	.39910	.080287	.40155
23	.41903	.088543	.42174
24	.43923	.097325	.44221
25	.45971	.106662	.46299
26	.48050	.116579	.48410
27	.50162	.127107	.50555
28	.52308	.138279	.52737
29	.54490	.150130	.54958
30	.56712	.162699	.57220
31	.58974	.176029	.59527
32	.61281	.190164	.61880
33	.63633	.205154	.64282

γ = 0,03

φ	X	Y	T
34°	.66035	.221054	.66738
35	.68490	.237922	.69249
36	.70999	.255823	.71820
37	.73567	.274828	.74454
38	.76197	.295012	.77154
39	.78893	.316461	.79926
40	.81659	.339267	.82774
41	.84500	.363530	.85702
42	.87419	.389362	.88716
43	.90423	.416885	.91822
44	.93515	.446235	.95024
45	.96702	.477561	.98331
46	.99991	.511027	1.01749
47	1.03386	.546814	1.05286
48	1.06897	.585125	1.08950
49	1.10529	.626186	1.12750
50	1.14291	.670247	1.16696
51	1.18193	.717586	1.20799
52	1.22243	.768515	1.25070
53	1.26452	.823382	1.29523
54	1.30832	.882577	1.34171
55	1.35393	.946541	1.39031
56	1.40150	1.015767	1.44118
57	1.45116	1.090812	1.49453
58	1.50307	1.172306	1.55055
59	1.55738	1.260959	1.60949
60	1.61429	1.357583	1.67159

γ = 0.04

φ	X	Y	T
60°	1.96194	1.79302	1.84116
59	1.86669	1.63124	1.76082
58	1.77967	1.48920	1.68623
57	1.69963	1.36351	1.61666
56	1.62556	1.25157	1.55151
55	1.55667	1.15130	1.49029
54	1.49231	1.06105	1.43256
53	1.43195	.97945	1.37799
52	1.37514	.90540	1.32626
51	1.32150	.83795	1.27711
50	1.27071	.77632	1.23030
49	1.22249	.71985	1.18563
48	1.17661	.66798	1.14292
47	1.13285	.62022	1.10201
46	1.09102	.57614	1.06275

γ = 0.04				γ = 0.04			
φ	X	Y	T	φ	X	Y	T
45°	1.05097	.53538	1.02503	−1°	.01745	.000152	.01745
44	1.01256	.49762	.98873	2	.03487	.000609	.03490
43	.97564	.46258	.95373	3	.05230	.001370	.05235
42	.94011	.43002	.91996	4	.06973	.002435	.06983
41	.90587	.39971	.88731	5	.08719	.003809	.08734
40	.87281	.37147	.85572	6	.10467	.005493	.10488
39	.84085	.34513	.82511	7	.12219	.007489	.12249
38	.80992	.32052	.79542	8	.13976	.009802	.14015
37	.77995	.29752	.76659	9	.15739	.012437	.15788
36	.75086	.27599	.73856	10	.17510	.015401	.17571
35	.72261	.25584	.71128	11	.19288	.018698	.19363
34	.69513	.23695	.68471	12	.21076	.022336	.21166
33	.66838	.21924	.65880	13	.22875	.026325	.22981
32	.64231	.20263	.63350	14	.24686	.030671	.24810
31	.61688	.18704	.60879	15	.26509	.035388	.26652
30	.59204	.172413	.58463	16	.28347	.040486	.28510
29	.56777	.158678	.56098	17	.30200	.045976	.30386
28	.54402	.145783	.53782	18	.32071	.051874	.32281
27	.52077	.133677	.51510	19	.33960	.058195	.34196
26	.49798	.122314	.49282	20	.35868	.064953	.36131
25	.47563	.111652	.47094	21	.37798	.072167	.38091
24	.45369	.101651	.44943	22	.39750	.079857	.40075
23	.43213	.092276	.42828	23	.41726	.088044	.42085
22	.41093	.083494	.40746	24	.43728	.096749	.44123
21	.39007	.075276	.38695	25	.45758	.105999	.46191
20	.36953	.067596	.36673	26	.47817	.115820	.48292
19	.34928	.060427	.34679	27	.49907	.126241	.50426
18	.32932	.053746	.32711	28	.52030	.137294	.52596
17	.30961	.047532	.30766	29	.54188	.149013	.54805
16	.29015	.041766	.28844	30	.56383	.161436	.57054
15	.27091	.036430	.26942	31	.58618	.174602	.59346
14	.25189	.031509	.25060	32	.60895	.188556	.61684
13	.23306	.026988	.23195	33	.63216	.203346	.64071
12	.21441	.022853	.21348	34	.65585	.219024	.66509
11	.19592	.019092	.19515	35	.68003	.235647	.69002
10	.17759	.015695	.17697	36	.70474	.253275	.71553
9	.15940	.012651	.15889	37	.73001	.271977	.74166
8	.14134	.009951	.14094	38	.75588	.291827	.76844
7	.12340	.007588	.12309	39	.78237	.312903	.79592
6	.10555	.005555	.10532	40	.80953	.335295	.82414
5	.08780	.003845	.08764	41	.83740	.359099	.85314
4	.07012	.002454	.07003	42	.86602	.384420	.88298
3	.05252	.001377	.05247	43	.89543	.411374	.91371
2	.03497	.000611	.03494	44	.92568	.440090	.94539
+1	.01747	.000152	.01746	45	.95683	.470706	.97809
	+	+	+	46	.98894	.503379	1.01186
0	00000	000000	00000	47	1.02205	.538280	1.04679
				48	1.05624	.575598	1.08295

$\gamma = 0.04$

φ	X	Y	T
49°	1.09158	.615542	1.12043
50	1.12813	.658346	1.15932
51	1.16598	.704267	1.19973
52	1.20521	.753593	1.24176
53	1.24591	.806644	1.28555
54	1.28817	.863779	1.33122
55	1.33212	.925397	1.37891
56	1.37785	.991947	1.42879
57	1.42548	1.063932	1.48104
58	1.47515	1.141917	1.53584
59	1.52700	1.226536	1.59342
60	1.58116	1.318507	1.65401

$\gamma = 0.05$

φ	X	Y	T
60°	2.04361	1.90178	1.87718
59	1.93605	1.71908	1.79181
58	1.83932	1.56116	1.71316
57	1.75143	1.42316	1.64026
56	1.67093	1.30150	1.57234
55	1.59669	1.19344	1.50878
54	1.52782	1.09686	1.44908
53	1.46362	1.01007	1.39280
52	1.40351	.93171	1.33958
51	1.34701	.86067	1.28914
50	1.29373	.79602	1.24119
49	1.24333	.73699	1.19552
48	1.19551	.68293	1.15192
47	1.15004	.63329	1.11022
46	1.10669	.58760	1.07025
45	1.06527	.54544	1.03189
44	1.02563	.50647	.99501
43	.98759	.47039	.95949
42	.95106	.43690	.92524
41	.91591	.40579	.89217
40	.88202	.37684	.86018
39	.84931	.34987	.82921
38	.81768	.32471	.79919
37	.78707	.30122	.77006
36	.75740	.27926	.74175
35	.72861	.25873	.71421
34	.70064	.23950	.68740
33	.67343	.22149	.66127
32	.64694	.20461	.63577
31	.62112	.18878	.61087

$\gamma = 0.05$

φ	X	Y	T
30°	.59593	.173941	.58653
29	.57131	.160017	.56272
28	.54726	.146954	.53941
27	.52372	.134698	.51655
26	.50067	.123201	.49414
25	.47806	.112420	.47214
24	.45589	.102314	.45052
23	.43412	.092847	.42926
22	.41272	.083983	.40834
21	.39168	.075692	.38774
20	.37096	.067948	.36744
19	.35056	.060724	.34742
18	.33045	.053993	.32767
17	.31061	.047737	.30815
16	.29103	.041934	.28887
15	.27167	.036566	.26980
14	.25254	.031618	.25093
13	.23362	.027075	.23223
12	.21488	.022920	.21372
11	.19631	.019143	.19535
10	.17791	.015733	.17713
9	.15966	.012678	.15902
8	.14154	.009970	.14104
7	.12355	.007600	.12316
6	.10566	.005563	.10538
5	.08788	.003850	.08768
4	.07017	.002457	.07005
3	.05255	.001378	.05248
2	.03498	.000612	.03495
+1	.01747	.000152	.01747
	+	+	+
0	00000	000000	00000
	—	+	—
−1°	.01745	.000152	.01745
2	.03486	.000609	.03489
3	.05227	.001369	.05234
4	.06968	.002433	.06980
5	.08711	.003805	.08730
6	.10456	.005485	.10483
7	.12204	.007477	.12241
8	.13956	.009784	.14005
9	.15714	.012411	.15776
10	.17479	.015365	.17556
11	.19251	.018651	.19345
12	.21032	.022273	.21144
13	.22823	.026245	.22955
14	.24625	.030571	.24779
15	.26439	.035263	.26616

γ = 0,05				γ = 0,06			
φ	X	Y	T	φ	X	Y	T
16°	.28267	.040334	.28470	60°	2.14308	2.03739	1.91913
17	.30110	.045792	.30340	59	2.01825	1.82534	1.82716
18	.31969	.051653	.32229	58	1.90851	1.64619	1.74339
19	.33845	.057932	.34138	57	1.81053	1.49233	1.66642
20	.35740	.064643	.36067	56	1.72199	1.35850	1.59520
21	.37655	.071804	.38018	55	1.64122	1.24094	1.52890
22	.39592	.079434	.39995	54	1.56696	1.13679	1.46690
23	.41552	.087553	.41996	53	1.49824	1.04390	1.40867
24	.43537	.096183	.44026	52	1.43431	.96056	1.35379
25	.45548	.105349	.46085	51	1.37454	.88540	1.30191
26	.47587	.115076	.48175	50	1.31844	.81732	1.25271
27	.49656	.125393	.50299	49	1.26558	.75542	1.20594
28	.51757	.136330	.52457	48	1.21561	.69894	1.16137
29	.53891	.147920	.54654	47	1.16824	.64723	1.11881
30	.56061	.160200	.56890	46	1.12322	.59977	1.07808
31	.58269	.173208	.59168	45	1.08031	.55610	1.03903
32	.60518	.186988	.61492	44	1.03933	.51582	1.00153
33	.62809	.201584	.63863	43	1.00010	.47860	.96546
34	.65145	.217048	.66284	42	.96249	.44412	.93071
35	.67529	.233433	.68759	41	.92636	.41215	.89718
36	.69963	.250799	.71291	40	.89158	.38245	.86478
37	.72451	.269211	.73884	39	.85807	.35481	.83343
38	.74996	.288738	.76540	38	.82571	.32907	.80307
39	.77600	.309458	.79264	37	.79443	.30506	.77361
40	.80268	.331455	.82061	36	.76415	.28265	.74501
41	.83004	.354821	.84935	35	.73479	.26171	.71721
42	.85811	.379656	.87890	34	.70631	.24213	.69015
43	.88693	.406069	.90932	33	.67862	.22380	.66379
44	.91655	.434183	.94067	32	.65169	.20665	.63808
45	.94702	.464131	.97300	31	.62547	.19057	.61299
46	.97839	.496058	1.00639	30	.59990	.175509	.58847
47	1.01071	.530125	1.04089	29	.57494	.161389	.56449
48	1.04405	.566510	1.07660	28	.55057	.148151	.54102
49	1.07846	.605410	1.11358	27	.52673	.135741	.51803
50	1.11401	.647042	1.15194	26	.50340	.124107	.49548
51	1.15077	.691646	1.19176	25	.48054	.113204	.47335
52	1.18882	.739489	1.23316	24	.45813	.102991	.45162
53	1.22824	.790867	1.27625	23	.43614	.093428	.43025
54	1.26911	.846111	1.32116	22	.41454	.084480	.40923
55	1.31153	.905589	1.36802	21	.39331	.076116	.38854
56	1.35559	.969709	1.41698	20	.37242	.068306	.36816
57	1.40139	1.038928	1.46821	19	.35186	.061024	.34806
58	1.44905	1.113758	1.52190	18	.33160	.054244	.32823
59	1.49869	1.194772	1.57823	17	.31162	.047945	.30865
60	1.55041	1.282610	1.63744	16	.29191	.042104	.28931
				15	.27244	.036704	.27018
				14	.25320	.031728	.25125
				13	.23418	.027162	.23251

$\gamma = 0.06$

φ	X	Y	T
12°	.21535	.022988	.21395
11	.19670	.019194	.19554
10	.17824	.015771	.17729
9	.15992	.012706	.15915
8	.14175	.009989	.14114
7	.12371	.007613	.12324
6	.10577	.005571	.10544
5	.08795	.003854	.08772
4	.07022	.002459	.07007
3	.05257	.001379	.05249
2	.03499	.000612	.03496
+1	.01748	.000152	.01747
	+	+	+
0	00000	000000	00000
	−	+	−
−1°	.01744	.000152	.01745
2	.03484	.000608	.03488
3	.05224	.001368	.05233
4	.06963	.002431	.06978
5	.08703	.003801	.08726
6	.10445	.005478	.10478
7	.12189	.007465	.12234
8	.13937	.009766	.13995
9	.15690	.012385	.15764
10	.17449	.015330	.17541
11	.19214	.018603	.19326
12	.20988	.022212	.21122
13	.22772	.026165	.22929
14	.24565	.030471	.24749
15	.26370	.035140	.26581
16	.28188	.040183	.28430
17	.30020	.045610	.30295
18	.31867	.051435	.32178
19	.33732	.057673	.34080
20	.35614	.064337	.36002
21	.37515	.071446	.37947
22	.39437	.079016	.39916
23	.41381	.087070	.41909
24	.43348	.095626	.43930
25	.45341	.104709	.45980
26	.47361	.114345	.48060
27	.49410	.124559	.50173
28	.51489	.135383	.52320
29	.53600	.146849	.54505
30	.55746	.158990	.56729
31	.57928	.171845	.58994
32	.60149	.185455	.61303
33	.62410	.199864	.63658
34°	.64715	.215120	.66063
35	.67065	.231277	.68521
36	.69464	.248390	.71035
37	.71915	.266522	.73607
38	.74419	.285740	.76242
39	.76981	.306119	.78944
40	.79603	.327738	.81717
41	.82289	.350684	.84564
42	.85044	.375055	.87492
43	.87870	.400955	.90504
44	.90772	.428499	.93607
45	.93754	.457812	.96806
46	.96822	.489034	1.00108
47	.99980	.522316	1.03518
48	1.03233	.557825	1.07046
49	1.06588	.595747	1.10697
50	1.10049	.636285	1.14482
51	1.13625	.679664	1.18410
52	1.17320	.726132	1.22490
53	1.21144	.775964	1.26734
54	1.25102	.829467	1.31153
55	1.29204	.886981	1.35761
56	1.33457	.948882	1.40572
57	1.37871	1.015585	1.45601
58	1.42456	1.087557	1.50866
59	1.47220	1.165322	1.56386
60	1.52175	1.249463	1.62181

$\gamma = 0.07$

φ	X	Y	T
60°	2.27039	2.21597	1.96977
59	2.11908	1.95891	1.86852
58	1.99085	1.74955	1.77798
57	1.87926	1.57430	1.69584
56	1.78031	1.42473	1.62054
55	1.69135	1.29524	1.55096
54	1.61049	1.18185	1.48627
53	1.53638	1.08165	1.42580
52	1.46794	.99244	1.36902
51	1.40439	.91252	1.31552
50	1.34506	.84053	1.26492
49	1.28942	.77537	1.21694
48	1.23705	.71616	1.17131
47	1.18757	.66215	1.12781
46	1.14070	.61274	1.08626

ϒ = 0,07				ϒ = 0,07			
φ	X	Y	T	φ	X	Y	T
45°	1.09615	.56741	1.04648	−1°	.01744	.000152	.01745
44	1.05372	.52571	1.00832	2	.03483	.000608	.03488
43	1.01320	.48725	.97165	3	.05222	.001367	.05231
42	.97443	.45171	.93637	4	.06959	.002428	.06975
41	.93724	.41882	.90236	5	.08696	.003796	.08722
40	.90153	.38830	.86952	6	.10434	.005470	.10472
39	.86716	.35996	.83777	7	.12174	.007453	.12226
38	.83402	.33360	.80705	8	.13918	.009748	.13986
37	.80203	.30905	.77726	9	.15666	.012360	.15752
36	.77110	.28616	.74836	10	.17419	.015294	.17526
35	.74116	.26480	.72028	11	.19178	.018556	.19308
34	.71215	.24485	.69296	12	.20945	.022151	.21100
33	.68395	.22619	.66637	13	.22721	.026088	.22903
32	.65656	.20874	.64044	14	.24506	.030373	.24719
31	.62992	.19241	.61515	15	.26301	.035018	.26546
30	.60396	.177118	.59044	16	.28110	.040034	.28390
29	.57864	.162794	.56629	17	.29931	.045430	.30250
28	.55394	.149377	.54266	18	.31767	.051219	.32127
27	.52980	.136807	.51952	19	.33620	.057416	.34023
26	.50618	.125032	.49684	20	.35488	.064035	.35939
25	.48306	.114005	.47458	21	.37376	.071092	.37877
24	.46041	.103681	.45273	22	.39283	.078605	.39837
23	.43820	.094020	.43125	23	.41211	.086593	.41823
22	.41639	.084986	.41014	24	.43162	.095078	.43835
21	.39496	.076546	.38935	25	.45138	.104080	.45876
20	.37390	.068670	.36889	26	.47139	.113626	.47946
19	.35317	.061330	.34871	27	.49168	.123742	.50049
18	.33276	.054498	.32880	28	.51226	.134455	.52186
17	.31264	.048154	.30915	29	.53315	.145799	.54359
16	.29280	.042276	.28975	30	.55436	.157805	.56570
15	.27321	.036843	.27056	31	.57593	.170511	.58822
14	.25386	.031840	.25158	32	.59787	.183957	.61117
13	.23475	.027250	.23279	33	.62020	.198184	.63457
12	.21583	.023056	.21419	34	.64295	.213240	.65847
11	.19710	.019246	.19574	35	.66613	.229175	.68288
10	.17856	.015809	.17745	36	.68978	.246045	.70783
9	.16018	.012734	.15928	37	.71391	.263907	.73337
8	.14195	.010008	.14124	38	.73857	.282829	.75951
7	.12386	.007626	.12332	39	.76377	.302880	.78631
6	.10588	.005579	.10550	40	.78956	.324136	.81381
5	.08802	.003859	.08776	41	.81595	.346683	.84203
4	.07027	.002461	.07010	42	.84300	.370611	.87104
3	.05260	.001380	.05251	43	.87072	.396021	.90088
2	.03500	.000612	.03496	44	.89917	.423022	.93160
+1	.01748	.000153	.01747	45	.92839	.451733	.96326
	+	+	+	46	.95841	.482286	.99592
0	00000	000000	00000	47	.98928	.514825	1.02965
				48	1.02106	.549509	1.06451

$\gamma = 0.07$

φ	X	Y	T
49°	1.05379	.586512	1.10058
50	1.08754	.626026	1.13795
51	1.12234	.668261	1.17670
52	1.15828	.713449	1.21693
53	1.19541	.761847	1.25876
54	1.23381	.813741	1.30228
55	1.27353	.869445	1.34763
56	1.31467	.929307	1.39494
57	1.35729	.993714	1.44436
58	1.40148	1.063094	1.49605
59	1.44733	1.137924	1.55019
60	1.49492	1.218733	1.60698

$\gamma = 0.08$

φ	X	Y	T
60°	2.44854	2.47491	2.03488
59	2.24980	2.13716	1.91887
58	2.09255	1.88037	1.81862
57	1.96134	1.67428	1.72956
56	1.84826	1.50334	1.64906
55	1.74864	1.35834	1.57545
54	1.65951	1.23333	1.50752
53	1.57878	1.12419	1.44441
52	1 50497	1.02797	1.38545
51	1.43696	.94244	1.33010
50	1.37389	.86591	1.27794
49	1.31509	.79704	1.22860
48	1.25999	.73476	1.18180
47	1.20817	.67819	1.13728
46	1.15924	.62662	1.09483
45	1.11290	.57945	1.05425
44	1.06888	.53619	1.01539
43	1.02695	.49639	.97809
42	.98692	.45970	.94224
41	.94861	.42581	.90771
40	.91188	.39443	.87442
39	.87660	.36534	.84225
38	.84264	33832	.81114
37	.80990	.31320	.78101
36	.77829	.28980	.75179
35	.74773	.26800	.72342
34	.71813	.24765	.69584
33	.68943	.22865	.66900
32	.66156	.21090	.64285
31	.63447	.19430	.61735
30°	.60811	.178769	.59245
29	.58243	.164235	.56813
28	.55738	.150632	.54433
27	.53292	.137898	.52104
26	.50901	.125978	.49821
25	.48562	.114822	.47583
24	.46272	.104384	.45386
23	.44028	.094623	.43227
22	.41826	.085501	.41105
21	.39664	.076983	.39017
20	.37539	.069039	.36962
19	.35449	.061639	.34936
18	.33393	.054756	.32938
17	.31367	.048366	.30966
16	.29369	.042449	.29019
15	.27399	.036984	.27094
14	.25453	.031952	.25191
13	.23532	.027338	.23307
12	.21631	.023125	.21442
11	.19750	.019299	.19593
10	.17889	.015848	.17761
9	.16044	.012761	.15941
8	.14216	.010028	.14135
7	.12402	.007639	.12339
6	.10600	.005587	.10555
5	.08811	.003864	.08780
4	.07032	.002463	.07012
3	.05263	.001381	.05252
2	.03502	.000612	.03497
+1	.01748	.000153	.01747
	+	+	+
0	00000	000000	00000
	−	+	−
−1	.01744	.000152	.01745
2	.03482	.000608	.03487
3	.05219	.001366	.05230
4	.06954	.002426	.06973
5	.08688	.003792	.08719
6	.10424	.005462	.10467
7	.12160	.007441	.12219
8	.13899	.009730	.13976
9	.15641	.012334	.15739
10	.17389	.015259	.17510
11	.19142	.018509	.19290
12	.20902	.022090	.21079
13	.22670	.026010	.22877
14	.24447	.030275	.24689
15	.26233	.034897	.26512

γ = 0.08				γ = 0.09			
φ	X	Y	T	φ	X	Y	T
16°	.28032	.039887	.28351	°	+	+	+
17	.29843	.045251	.30205	59	2.43774	2.40308	1.98477
18	.31668	.051006	.32077	58	2.22605	2.05726	1.86850
19	.33509	.057164	.33967	57	2.06336	1.80168	1.76934
20	.35365	.063737	.35876	56	1.92967	1.59956	1.68182
21	.37238	.070744	.37807	55	1.81551	1.43338	1.60302
22	.39131	.078200	.39760	54	1.71558	1.29321	1.53110
23	.41044	.086125	.41738	53	1.62653	1.17283	1.46482
24	.42979	.094538	.43742	52	1.54614	1.06802	1.40328
25	.44937	.103462	.45773	51	1.47280	.97579	1.34581
26	.46920	.112920	.47834	50	1.40535	.89393	1.29186
27	.48929	.122939	.49927	49	1.34287	.82076	1.24101
28	.50967	.133545	.52053	48	1.28467	.75496	1.19291
29	.53034	.144770	.54214	47	1.23020	.69549	1.14727
30	.55132	.156645	.56413	46	1.17897	.64151	1.10383
31	.57265	.169207	.58652	45	1.13065	.59231	1.06239
32	.59432	.182492	.60933	44	1.08488	.54733	1.02276
33	.61638	.196544	.63260	43	1.04141	.50607	.98479
34	.63883	.211406	.65634	42	1.00002	.46813	.94833
35	.66170	.227128	.68058	41	.96050	.43316	.91326
36	.68502	.243762	.70536	40	.92268	.40086	.87947
37	.70881	.261365	.73071	39	.88642	.37096	.84687
38	.73309	.280001	.75666	38	.85159	.34324	.81536
39	.75790	.299737	.78325	37	.81805	.31751	.78487
40	.78326	.320646	.81052	36	.78572	.29358	.75532
41	.80921	.342809	.83850	35	.75450	.27131	.72664
42	.83577	.366314	.86725	34	.72430	.25055	.69878
43	.86299	.391257	.89682	33	.69506	.23119	.67169
44	.89090	.417741	.92724	32	.66669	.21313	.64531
45	.91953	.445881	.95859	31	.63914	.19624	.61959
46	.94893	.475801	.99091	30	.61237	.180466	.59450
47	.97914	.507638	1.02427	29	.58630	.165714	.56999
48	1.01020	.541543	1.05873	28	.56089	.151918	.54603
49	1.04217	.577681	1.09438	27	.53610	.139014	.52258
50	1.07509	.616232	1.13129	26	.51190	.126944	.49961
51	1.10901	.657393	1.16955	25	.48823	.115655	.47710
52	1.14400	.701385	1.20925	24	.46508	.105100	.45500
53	1.18011	.748448	1.25049	23	.44239	.095236	.43330
54	1.21740	.798848	1.29338	22	.42015	.086024	.41198
55	1.25593	.852879	1.33804	21	.39833	.077427	.39100
56	1.29577	.910864	1.38461	20	.37690	.069413	.37036
57	1.33700	.973161	1.43321	19	.35583	.061952	.35002
58	1.37968	1.040167	1.48401	18	.33511	.055016	.32996
59	1.42389	1.112321	1.53718	17	.31470	.048581	.31017
60	1.46970	1.190111	1.59290	16	.29460	.042625	.29063
				15	.27478	.037126	.27133
				14	.25521	.032066	.25224
				13	.23589	.027428	.23336

$\gamma = 0.09$

φ	X	Y	T
12°	.21679	.023194	.21466
11	.19790	.019351	.19613
10	.17922	.015887	.17777
9	.16070	.012790	.15954
8	.14236	.010047	.14145
7	.12417	.007652	.12347
6	.10611	.005595	.10561
5	.08819	.003868	.08784
4	.07037	.002466	.07015
3	.05266	.001382	.05254
2	.03503	.000612	.03497
+1	.01749	.000153	.01747
	+	+	+
0	00000	000000	00000
	—	+	—
−1	.01743	.000152	.01745
2	.03481	.000607	.03487
3	.05217	.001365	.05228
4	.06949	.002424	.06970
5	.08681	.003787	.08715
6	.10413	.005455	.10461
7	.12145	.007429	.12211
8	.13880	.009713	.13967
9	.15617	.012309	.15727
10	.17359	.015224	.17495
11	.19106	.018462	.19271
12	.20859	.022029	.21057
13	.22619	.025932	.22852
14	.24388	.030179	.24654
15	.26166	.034779	.26478
16	.27955	.039741	.28312
17	.29756	.045075	.30161
18	.31570	.050795	.32027
19	.33399	.056914	.33911
20	.35242	.063443	.35814
21	.37103	.070400	.37737
22	.38981	.077800	.39684
23	.40879	.085663	.41654
24	.42798	.094007	.43649
25	.44740	.102854	.45672
26	.46704	.112227	.47724
27	.48695	.122151	.49807
28	.50712	.132653	.51922
29	.52758	.143761	.54072
30	.54834	.155509	.56259
31	.56942	.167930	.58486
32	.59085	.181061	.60754
33	.61263	.194942	.63066

$\gamma = 0.09$

φ	X	Y	T
34°	.63480	.209616	.65425
35	.65738	.225131	.67833
36	.68037	.241538	.70294
37	.70382	.258891	.72811
38	.72775	.277251	.75387
39	.75218	.296684	.78025
40	.77713	.317260	.80730
41	.80265	.339056	.83506
42	.82876	.362156	.86356
43	.85549	.386652	.89286
44	.88287	.412643	.92300
45	.91095	.440239	.95404
46	.93976	.469558	.98603
47	.96934	.500731	1.01904
48	.99972	.533901	1.05313
49	1.03097	.569223	1.08837
50	1.06311	.606867	1.12485
51	1.09621	.647021	1.16263
52	1.13031	.689892	1.20182
53	1.16546	.735708	1.24251
54	1.20172	.784717	1.28481
55	1.23914	.837193	1.32882
56	1.27779	.893440	1.37468
57	1.31773	.953792	1.42252
58	1.35902	1.018617	1.47249
59	1.40173	1.088323	1.52475
60	1.44592	1.163360	1.57947

$\gamma = 0.10$

φ	X	Y	T
58°	2.42326	2.32865	1.93480
57	2.19876	1.97583	1.81849
56	2.03136	1.72270	1.72059
55	1.89581	1.52534	1.63472
54	1.78106	1.36438	1.55766
53	1.68116	1.22932	1.48746
52	1.59248	1.11371	1.42283
51	1.51262	1.01330	1.36286
50	1.43993	.925075	1.30685
49	1.37315	.846868	1.25428
48	1 31137	.777020	1.20472
47	1.25387	.714251	1.15783
46	1.20007	.657546	1.11331

γ = 0.10				γ = 0.10			
φ	X	Y	T	φ	X	Y	T
45°	1.14951	.606087	1.07093	−1°	.01743	.000152	.01744
44	1.10182	.559206	1.03047	2	.03480	.000607	.03486
43	1.05666	.516347	.99177	3	.05214	.001364	.05227
42	1.01378	.477046	.95466	4	.06944	.002422	.06968
41	.97295	.440911	.91902	5	.08673	.003783	.08711
40	.93396	.407608	.88471	6	.10402	.005447	.10456
39	.89665	.376850	.85164	7	.12130	.007417	.12204
38	.86088	.348387	.81971	8	.13861	.009695	.13957
37	.82650	.322004	.78884	9	.15593	.012284	.15715
36	.79341	.297513	.75894	10	.17329	.015190	.17480
35	.76149	.274747	.72995	11	.19070	.018416	.19253
34	.73067	.253559	.70180	12	.20816	.021969	.21035
33	.70085	.233820	.67445	13	.22569	.025856	.22826
32	.67196	.215416	.64782	14	.24330	.030083	.24629
31	.64394	.198242	.62188	15	.26099	.034660	.26444
30	.61673	.182208	.59659	16	.27879	.039596	.28273
29	.59026	.167230	.57189	17	.29670	.044901	.30117
28	.56448	.153234	.54776	18	.31473	.050587	.31977
27	.53936	.140154	.52415	19	.33290	.056667	.33855
26	.51484	.127928	.50103	20	.35121	.063153	.35752
25	.49089	.116503	.47838	21	.36969	.070061	.37669
24	.46747	.105828	.45616	22	.38834	.077406	.39608
23	.44454	.095858	.43435	23	.40717	.085208	.41570
22	.42208	.086553	.41292	24	.42620	.093484	.43558
21	.40005	.077875	.39184	25	.44545	.102256	.45572
20	.37843	.069790	.37110	26	.46492	.111545	.47614
19	.35719	.062268	.35068	27	.48464	.121376	.49687
18	.33630	.055279	.33054	28	.50461	.131776	.51793
17	.31575	.048799	.31069	29	.52487	.142772	.53932
16	.29551	.042803	.29108	30	.54541	.154396	.56108
15	.27557	.037270	.27172	31	.56626	.166680	.58322
14	.25589	.032181	.25258	32	.58744	.179660	.60577
13	.23647	.027518	.23364	33	.60897	.193376	.62875
12	.21728	.023264	.21490	34	.63086	.207868	.65219
11	.19831	.019404	.19633	35	.65314	.223183	.67612
10	.17955	.015926	.17793	36	.67583	.239370	.70057
9	.16097	.012818	.15967	37	.69896	.256482	.72556
8	.14257	.010067	.14155	38	.72254	.274577	.75113
7	.12433	.007665	.12355	39	.74660	293718	.77732
6	.10623	.005603	.10567	40	.77117	.313973	.80415
5	.08827	.003873	.08788	41	.79627	.335417	.83168
4	.07042	.002468	.07017	42	.82194	.358129	.85994
3	.05269	.001383	.05255	43	.84820	.382198	.88898
2	.03504	.000613	.03498	44	.87510	.407719	.91885
+1	.01749	.000153	.01747	45	.90265	.434796	.94960
	+	+	+	46	.93089	.463544	.98128
0	00000	000000	00000	47	.95987	.494086	1.01395
				48	.98962	.526557	1.04768

γ = 0.10

φ	X	Y	T
49°	1.02018	.561106	1.08254
50	1.05160	.597895	1.11860
51	1.08391	.637102	1.15593
52	1.11717	.678923	1.19464
53	1.15143	.723571	1.23481
54	1.18672	.771281	1.27654
55	1.22312	.822311	1.31994
56	1.26066	.876946	1.36514
57	1.29941	.935498	1.41226
58	1.33942	.998312	1.46145
59	1.38075	1.065767	1.51286
60	1.42345	1.138282	1.56665

γ = 0.11

φ	X	Y	T
57°	2.40402	2.25049	1.88501
56	2.16753	1.89271	1.76874
55	1.99642	1.64352	1.67229
54	1.85974	1.45177	1.58819
53	1.74491	1.29650	1.51294
52	1.64542	1.16679	1.44448
51	1.55739	1.05607	1.38151
50	1.47829	.96008	1.32310
49	1.40639	.87587	1.26855
48	1.34042	.80128	1.21734
47	1.27944	.73471	1.16905
46	1.22271	.67491	1.12334
45	1.16965	.62091	1.07992
44	1.11981	.57192	1.03857
43	1.07279	.52730	.99907
42	1.02827	.48651	.96127
41	.98601	.44910	.92501
40	.94576	.41471	.89015
39	.90733	.38304	.85658
38	.87055	.35377	.82420
37	.83528	.32669	.79293
36	.80137	.30160	.76267
35	.76873	.27832	.73335
34	.73724	.25668	.70490
33	.70682	.23654	.67727
32	.67739	.21779	.65039
31	.64887	.20030	.62422
30	.62120	.184005	.59872
29	.59431	.168790	.57383
28	.56815	.154589	.54952
27°	.54268	.141327	.52575
26	.51784	.128940	.50248
25	.49360	.117373	.47969
24	.46991	.106575	.45734
23	.44673	.096497	.43541
22	.42404	.087096	.41387
21	.40180	.078334	.39269
20	.37998	.070177	.37186
19	.35856	.062591	.35135
18	.33751	.055547	.33114
17	.31682	.049020	.31121
16	.29644	.042983	.29154
15	.27637	.037416	.27211
14	.25658	.032297	.25292
13	.23706	.027609	.23393
12	.21777	.023335	.21514
11	.19872	.019457	.19653
10	.17989	.015965	.17809
9	.16124	.012845	.15980
8	.14278	.010086	.14165
7	.12449	.007678	.12363
6	.10635	.005611	.10573
5	.08835	.003878	.08792
4	.07047	.002470	.07020
3	.05271	.001384	.05256
2	.03505	.000613	.03499
+1	.01749	.000153	.01748
	+	+	+
0	00000	000000	00000
	—	+	—
−1	.01743	.000152	.01744
2	.03478	.000607	.03485
3	.05211	.001363	.05225
4	.06939	.002418	.06965
5	.08666	.003779	.08707
6	.10391	.005440	.10451
7	.12116	.007405	.12197
8	.13842	.009677	.13948
9	.15569	.012259	.15703
10	.17300	.015156	.17465
11	.19034	.018370	.19235
12	.20774	.021910	.21014
13	.22519	.025780	.22801
14	.24272	.029988	.24600
15	.26033	.034543	.26411
16	.27804	.039453	.28234
17	.29585	.044728	.30073
18	.31377	.050381	.31928

$\gamma = 0{,}11$				$\gamma = 0{,}12$			
φ	X	Y	T	φ	X	Y	T
19°	.33182	.056423	.33800	56°	2.37888	2.16734	1.83487
20	.35002	.062866	.35691	55	2.13210	1.80775	1.71917
21	.36836	.069726	.37601	54	1.95854	1.56419	1.62444
22	.38688	.077018	.39533	53	1.82153	1.37892	1.54224
23	.40556	.084760	.41488	52	1.70717	1.22979	1.46886
24	.42444	.092970	.43467	51	1.60846	1.10564	1.40218
25	.44353	.101668	.45473	50	1.52134	.99992	1.34088
26	.46283	.110875	.47506	49	1.44320	.90839	1.28401
27	.48237	.120616	.49570	48	1.37225	.82817	1.23090
28	.50215	.130916	.51665	47	1.30720	.75716	1.18103
29	.52220	.141803	.53793	46	1.24710	.69382	1.13398
30	.54253	.153305	.55958	45	1.19122	.63693	1.08942
31	.56315	.165456	.58160	44	1.13897	.58557	1.04708
32	.58410	.178290	.60402	43	1.08989	.53899	1.00672
33	.60537	.191845	.62687	42	1.04359	.49655	.96817
34	.62700	.206161	.65017	41	.99976	.45777	.93124
35	.64900	.221282	.67394	40	.95814	.42221	.89579
36	.67139	.237256	.69823	39	.91850	.38953	.86170
37	.69420	.254135	.72305	38	.88064	.35941	.82885
38	.71744	.271974	.74844	37	.84440	.33160	.79715
39	.74115	.290835	.77443	36	.80963	.30587	.76651
40	.76535	.310781	.80106	35	.77622	.28203	.73684
41	.79006	.331886	.82837	34	.74403	.25991	.70808
42	.81530	.354226	.85640	33	.71298	.23935	.68016
43	.84112	.377886	.88520	32	.68298	.22023	.65303
44	.86754	.402958	.91480	31	.65394	.20243	.62662
45	.89459	.429541	.94526	30	.62579	.185852	.60090
46	.92230	.457744	.97664	29	.59847	.170393	.57581
47	.95071	.487685	1.00899	28	.57192	.155976	.55131
48	.97985	.519494	1.04237	27	.54608	.142525	.52737
49	1.00977	.553311	1.07686	26	.52091	.129973	.50395
50	1.04049	.589292	1.11252	25	.49636	.118261	.48102
51	1.07207	.627606	1.14943	24	.47239	.107335	.45854
52	1.10455	.668438	1.18768	23	.44896	.097145	.43648
53	1.13796	.711989	1.22735	22	.42603	.087647	.41483
54	1.17236	.758483	1.26854	21	.40358	.078800	.39355
55	1.20779	.808164	1.31137	20	.38156	.070569	.37263
56	1.24430	.861298	1.35594	19	.35996	.062919	.35203
57	1.28194	.918179	1.40239	18	.33875	.055820	.33174
58	1.32076	.979130	1.45084	17	.31790	.049244	.31173
59	1.36082	1.044507	1.50145	16	.29738	.043166	.29200
60	1.40216	1.114701	1.55438	15	.27718	.037563	.27251
				14	.25727	.032414	.25326
				13	.23765	.027701	.23422
				12	.21827	.023406	.21539
				11	.19917	.019511	.19673
				10	.18022	.016005	.17826

[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1.01474
[illegible]	[illegible]	[illegible]	.97557
[illegible]	[illegible]	[illegible]	.95773
[illegible]	[illegible]	[illegible]	.90165

γ = 0.13

φ	X	Y	T
39°	.93019	.39636	.86700
38	.89117	.36533	.83365
37	.85391	.33673	.80150
36	.81821	.31032	.77046
35	.78398	.28589	.74043
34	.75106	.26326	.71134
33	.71934	.24226	.68312
32	.68874	.22276	.65572
31	.65915	.20462	.62907
30	.63050	.187754	.60312
29	.60273	.172040	.57783
28	.57577	.157400	.55314
27	.54956	.143753	.52902
26	.52405	.131030	.50544
25	.49918	.119169	.48236
24	.47492	.108111	.45975
23	.45123	.097806	.43757
22	.42806	.088208	.41580
21	.40538	.079274	.39443
20	.38316	.070968	.37340
19	.36138	.063252	.35272
18	.34000	.056096	.33234
17	.31899	.049471	.31226
16	.29833	.043350	.29246
15	.27800	.037712	.27291
14	.25797	.032532	.25361
13	.23824	.027794	.23451
12	.21877	.023478	.21563
11	.19955	.019566	.19694
10	.18056	.016045	.17842
9	.16178	.012903	.16007
8	.14320	.010126	.14186
7	.12481	.007704	.12378
6	.10658	.005627	.10584
5	.08851	.003887	.08800
4	.07058	.002475	.07025
3	.05277	.001386	.05259
2	.03508	.000614	.03500
+1	.01750	.000153	.01748
	+	+	+
0	00000	000000	00000
	—	+	—
−1	.01742	.000152	.01744
2	.03476	.000606	.03484
3	.05206	.001361	.05223
4	.06930	.002415	.06961
5	.08651	.003770	.08700
6	.10370	.005425	.10440

γ = 0.13

φ	X	Y	T
7°	.12087	.007382	.12182
8	.13804	.009642	.13928
9	.15522	.012209	.15679
10	.17242	.015088	.17436
11	.18964	.018280	.19199
12	.20690	.021792	.20971
13	.22421	.025630	.22751
14	.24158	.029801	.24542
15	.25902	.034312	.26344
16	.27655	.039171	.28158
17	.29417	.044389	.29987
18	.31188	.049977	.31831
19	.32971	.055944	.33691
20	.34767	.062304	.35570
21	.36576	.069070	.37467
22	.38401	.076258	.39385
23	.40242	.083883	.41325
24	.42100	.091964	.43289
25	.43977	.100518	.45278
26	.45874	.109568	.47294
27	.47793	.119134	.49339
28	.49734	.129242	.51414
29	.51700	.139917	.53522
30	.53692	.151186	.55664
31	.55711	.163082	.57843
32	.57759	.175635	.60061
33	.59838	.188882	.62319
34	.61950	.202861	.64622
35	.64096	.217613	.66970
36	.66279	.233182	.69368
37	.68500	.249618	.71817
38	.70761	.266971	.74321
39	.73065	.285299	.76883
40	.75414	.304663	.79507
41	.77810	.325129	.82197
42	.80256	.346769	.84956
43	.82754	.369661	.87788
44	.85307	.393890	.90698
45	.87917	.419547	.93691
46	.90589	.446733	.96772
47	.93324	.475557	.99946
48	.96125	.506137	1.03219
49	.98997	.538603	1.06598
50	1.01943	.573094	1.10089
51	1.04965	.609765	1.13701
52	1.08068	.648783	1.17439
53	1.11256	.690331	1.21314
54	1.14532	.734609	1.25334

γ = 0,13

φ	X	Y	T
55°	1.17900	.781837	1.29510
56	1.21364	.832254	1.33852
57	1.24929	.886123	1.38371
58	1.28598	.943732	1.43082
59	1.32376	1.005397	1.47997
60	1.36267	1.071464	1.53132

γ = 0.14

φ	X	Y	T
54°	2.30632	1.98239	1.73297
53	2.04816	1.63293	1.62037
52	1.87425	1.40607	1.52992
51	1.73918	1.23615	1.45195
50	1.62737	1.10043	1.38250
49	1.53132	.98792	1.31946
48	1.44679	.89233	1.26149
47	1.37111	.80971	1.20770
46	1.30247	.73736	1.15741
45	1.23959	.67336	1.11015
44	1.18152	.61627	1.06551
43	1.12752	.56502	1.02319
42	1.07703	.51874	.98292
41	1.02959	.47676	.94450
40	.98483	.43853	.90775
39	.94245	.40358	.87250
38	.90218	.37155	.83862
37	.86381	.34210	.80600
36	.82714	.31496	.77453
35	.79203	.28991	.74412
34	.75833	.26674	.71469
33	.72591	.24528	.68616
32	.69467	.22538	.65848
31	.66451	.20689	.63157
30	.63535	.189715	.60538
29	.60711	.173734	.57988
28	.57972	.158861	.55500
27	.55312	.145012	.53071
26	.52725	.132113	.50696
25	.50206	.120097	.48373
24	.47750	.108904	.46098
23	.45354	.098481	.43868
22	.43012	.088780	.41679
21	.40722	.079757	.39531
20	.38479	.071373	.37418
19	.36282	.063590	.35341
18°	.34126	.056376	.33295
17	.32009	.049700	.31280
16	.29929	.043537	.29293
15	.27883	.037862	.27332
14	.25868	.032652	.25395
13	.23884	.027888	.23480
12	.21927	.023550	.21588
11	.19996	.019621	.19714
10	.18090	.016086	.17859
9	.16205	.012932	.16020
8	.14341	.010146	.14197
7	.12497	.007717	.12386
6	.10670	.005635	.10590
5	.08859	.003892	.08804
4	.07062	.002478	.07027
3	.05280	.001387	.05261
2	.03509	.000614	.03501
+1	.01750	.000153	.01748
	+	+	+
0	00000	000000	00000
	−	+	−
−1	.01742	.000152	.01744
2	.03475	.000606	.03484
3	.05203	.001360	.05222
4	.06925	.002413	.06958
5	.08643	.003766	.08696
6	.10358	.005417	.10434
7	.12072	.007370	.12175
8	.13787	.009625	.13919
9	.15499	.012185	.15667
10	.17213	.015054	.17421
11	.18929	.018235	.19181
12	.20649	.021734	.20950
13	.22372	.025556	.22726
14	.24102	.029708	.24513
15	.25838	.034198	.26311
16	.27581	.039032	.28120
17	.29334	.044222	.29944
18	.31095	.049778	.31783
19	.32867	.055709	.33637
20	.34651	.062028	.35510
21	.36449	.068749	.37401
22	.38260	.075886	.39312
23	.40087	.083454	.41245
24	.41931	.091472	.43201
25	.43793	.099958	.45182
26	.45674	.108931	.47190
27	.47576	.118413	.49225

$\gamma = 0.14$

φ	X	Y	T
28°	.49499	.128427	.51291
29	.51446	.139000	.53389
30	.53418	.150158	.55520
31	.55416	.161930	.57688
32	.57443	.174349	.59893
33	.59499	.187449	.62139
34	.61586	.201266	.64428
35	.63707	.215841	.66763
36	.65862	.231218	.69145
37	.68055	.247442	.71579
38	.70286	.264565	.74066
39	.72558	.282641	.76611
40	.74873	.301729	.79216
41	.77234	.321893	.81886
42	.79643	.343203	.84623
43	.82101	.365734	.87433
44	.84612	.389568	.90319
45	.87179	.414793	.93287
46	.89803	.441504	.96341
47	.92489	.469807	.99486
48	.95238	.499816	1.02729
49	.98055	.531655	1.06075
50	1.00941	.565458	1.09531
51	1.03901	.601371	1.13105
52	1.06938	.639555	1.16803
53	1.10055	.680185	1.20635
54	1.13256	.723452	1.24609
55	1.16545	.769562	1.28735
56	1.19924	.818746	1.33023
57	1.23399	.871253	1.37485
58	1.26973	.927355	1.42134
59	1.30648	.987352	1.46982
60	1.34430	1.051571	1.52045

$\gamma = 0.15$

φ	X	Y	T
53°	2.25742	1.88017	1.68106
52	1.99983	1.54391	1.57118
51	1.82819	1.32791	1.48331
50	1.69536	1.16667	1.40764
49	1.58558	1.03806	1.34024
48	1.49136	.93151	1.27905
47	1.40847	.84102	1.22275
46	1.33427	.76281	1.17047

$\gamma = 0.15$

φ	X	Y	T
45°	1.26697	.69430	1.12157
44	1.20531	.63368	1.07558
43	1.14836	.57963	1.03212
42	1.09539	.53107	.99087
41	1.04585	.48723	.95160
40	.99928	.44746	.91412
39	.95534	.41122	.87822
38	.91371	.37810	.84378
37	.87414	.34774	.81066
36	.83643	.31982	.77874
35	.80038	.29411	.74793
34	.76585	.27037	.71814
33	.73269	.24842	.68929
32	.70078	.22809	.66131
31	.67003	.20923	.63413
30	.64032	.191738	.60770
29	.61160	.175479	.58198
28	.58376	.160365	.55690
27	.55675	.146306	.53242
26	.53051	.133222	.50851
25	.50499	.121046	.48512
24	.48013	.109714	.46223
23	.45588	.099169	.43980
22	.43221	.089363	.41779
21	.40908	.080249	.39620
20	.38644	.071785	.37497
19	.36427	.063933	.35411
18	.34254	.056659	.33357
17	.32121	.049933	.31334
16	.30026	.043726	.29340
15	.27967	.038014	.27372
14	.25940	.032773	.25430
13	.23945	.027983	.23510
12	.21978	.023623	.21613
11	.20038	.019676	.19735
10	.18124	.016126	.17875
9	.16232	.012961	.16034
8	.14362	.010166	.14207
7	.12513	.007730	.12394
6	.10681	.005643	.10596
5	.08867	.003896	.08808
4	.07067	.002480	.07030
3	.05283	.001388	.05262
2	.03511	.000614	.03502
+1	.01751	.000153	.01749
	+	+	+
0	00000	000000	00000

γ = 0,15

φ	X	Y	T
[illegible]	[illegible]	.524947	1,05566
[illegible]	[illegible]	.558094	1,08980
[illegible]	[illegible]	.593287	1,12526
[illegible]	[illegible]	.630680	1,16186
[illegible]	[illegible]	.670440	1,19977
[illegible]	[illegible]	.712750	1,23907
[illegible]	[illegible]	.757808	1,27985
[illegible]	[illegible]	.805832	1,32223
[illegible]	[illegible]	.857060	1,36630
[illegible]	[illegible]	.911751	1,41220
[illegible]	[illegible]	.970188	1,46005
[illegible]	[illegible]	1,032683	1,50999

γ = [illegible]

φ	X	Y	T
[illegible]	[illegible]	[illegible]	1,62859
[illegible]	[illegible]	[illegible]	1,52223
[illegible]	[illegible]	[illegible]	1,43719
[illegible]	[illegible]	[illegible]	1,36392
[illegible]	[illegible]	[illegible]	1,29862
[illegible]	[illegible]	[illegible]	1,23927
[illegible]	[illegible]	[illegible]	1,18463
[illegible]	[illegible]	[illegible]	1,13385
[illegible]	[illegible]	[illegible]	1,08632
[illegible]	[illegible]	[illegible]	1,04157
[illegible]	[illegible]	[illegible]	,99925
[illegible]	[illegible]	[illegible]	,95906
[illegible]	[illegible]	[illegible]	,92078
[illegible]	[illegible]	[illegible]	,88423
[illegible]	[illegible]	[illegible]	,84914
[illegible]	[illegible]	[illegible]	,81548
[illegible]	[illegible]	[illegible]	[illegible]

γ = 0.16			
φ	X	Y	T
24°	.48281	.110541	.46350
23	.45827	.099872	.44093
22	.43434	.089958	.41881
21	.41097	.080750	.39710
20	.38811	.072204	.37578
19	.36574	.064281	.35481
18	.34383	.056947	.33419
17	.32234	.050169	.31388
16	.30124	.043918	.29387
15	.28051	.038168	.27413
14	.26012	.032895	.25465
13	.24006	.028078	.23539
12	.22029	.023696	.21638
11	.20081	.019731	.19756
10	.18159	.016167	.17892
9	.16260	.012990	.16047
8	.14384	.010186	.14218
7	.12529	.007744	.12402
6	.10693	.005652	.10602
5	.08875	.003901	.08812
4	.07073	.002482	.07033
3	.05286	.001389	.05263
2	.03512	.000614	.03502
+1	.01751	.000153	.01749
	+	+	+
0	00000	000000	00000
	—	+	—
−1	.01741	.000152	.01743
2	.03473	.000605	.03482
3	.05198	.001358	.05219
4	.06916	.002409	.06954
5	.08629	.003757	.08688
6	.10338	.005403	.10424
7	.12044	.007347	.12161
8	.13749	.009591	.13901
9	.15452	.012136	.15644
10	.17156	.014987	.17392
11	.18860	.018146	.19146
12	.20567	.021619	.20908
13	.22276	.025410	.22677
14	.23991	.029525	.24456
15	.25710	.033973	.26246
16	.27436	.038759	.28046
17	.29170	.043894	.29860
18	.30911	.049386	.31688
19	.32662	.055246	.33531
20	.34424	.061486	.35392
21	.36197	.068118	.37271

γ = 0.16			
φ	X	Y	T
22°	.37984	.075156	.39169
23	.39784	.082615	.41087
24	.41600	.090511	.43029
25	.43433	.098862	.44994
26	.45283	.107686	.46985
27	.47151	.117005	.49003
28	.49041	.126840	.51050
29	.50951	.137215	.53128
30	.52885	.148157	.55239
31	.54844	.159693	.57385
32	.56828	.171853	.59567
33	.58839	.184670	.61789
34	.60880	.198178	.64052
35	.62952	.212416	.66359
36	.65055	.227423	.68713
37	.67193	.243245	.71116
38	.69367	.259928	.73572
39	.71579	.277525	.76082
40	.73831	.296089	.78652
41	.76125	.315682	.81283
42	.78463	.336368	.83980
43	.80847	.358217	.86747
44	.83280	.381306	.89588
45	.85763	.405716	.92507
46	.88301	.431537	.95510
47	.90894	.458866	.98600
48	.93545	.487808	1.01785
49	.96259	.518477	1.05069
50	.99036	.550998	1.08459
51	1.01880	.585506	1.11962
52	1.04794	.622148	1.15585
53	1.07782	.661084	1.19336
54	1.10845	.702489	1.23224
55	1.13987	.746553	1.27257
56	1.17212	.793483	1.31446
57	1.20523	.843506	1.35801
58	1.23922	.896870	1.40335
59	1.27412	.953845	1.45060
60	1.30998	1.014728	1.49989

$\gamma = 0.17$				$\gamma = 0.17$			
φ	X	Y	T	φ	X	Y	T
51°	2.13564	1.66158	1.57577	3°	.05288	.001390	.05265
50	1.89240	1.36603	1.47358	2	.03513	.000615	.03503
49	1.72971	1.17536	1.39159	+1	.01751	.000153	.01749
48	1.60356	1.03268	1.32079		+	+	+
47	1.49914	.91866	1.25760	0	00000	000000	00000
46	1.40939	.82405	1.20011		−	+	−
45	1.33034	.74358	1.14712	−1	.01741	.000152	.01743
44	1.25950	.67394	1.09782	2	.03472	.000605	.03482
43	1.19518	.61288	1.05163	3	.05195	.001357	.05218
42	1.13618	.55880	1.00811	4	.06911	.002406	.06952
41	1.08162	.51053	.96690	5	.08621	.003752	.08685
40	1.03083	.46714	.92775	6	.10328	.005395	.10419
39	.98329	.42795	.89042	7	.12031	.007335	.12154
38	.93856	.39236	.85471	8	.13731	.009574	.13891
37	.89630	.35992	.82048	9	.15429	.012112	.15632
36	.85624	.33028	.78759	10	.17127	.014954	.17377
35	.81813	.30309	.75591	11	.18826	.018102	.19129
34	.78177	.27809	.72534	12	.20526	.021562	.20887
33	.74698	.25506	.69579	13	.22229	.025338	.22652
32	.71363	.23381	.66718	14	.23936	.029435	.24428
31	.68157	.21417	.63944	15	.25647	.033862	.26213
30	.65071	.195981	.61250	16	.27364	.038624	.28009
29	.62093	.179130	.58631	17	.29089	.043732	.29818
28	.59215	.163500	.56080	18	.30821	.049193	.31641
27	.56428	.148994	.53594	19	.32561	.055019	.33479
26	.53727	.135523	.51167	20	.34312	.061220	.35334
25	.51104	.123011	.48797	21	.36074	.067808	.37206
24	.48554	.111386	.46479	22	.37848	.074798	.39098
23	.46072	.100590	.44208	23	.39636	.082204	.41010
22	.43651	.090564	.41984	24	.41438	.090041	.42944
21	.41289	.081259	.39801	25	.43256	.098326	.44901
20	.38981	.072629	.37659	26	.45091	.107078	.46884
19	.36724	.064634	.35553	27	.46944	.116318	.48893
18	.34514	.057238	.33482	28	.48817	.126066	.50931
17	.32348	.050407	.31443	29	.50710	.136347	.53000
16	.30224	.044112	.29435	30	.52625	.147184	.55101
15	.28137	.038324	.27454	31	.54564	.158606	.57236
14	.26085	.033019	.25500	32	.56528	.170642	.59407
13	.24067	.028175	.23569	33	.58518	.183323	.61617
12	.22081	.023770	.21663	34	.60537	.196683	.63868
11	.20123	.019788	.19777	35	.62584	.210759	.66162
10	.18193	.016208	.17909	36	.64663	.225591	.68502
9	.16287	.013019	.16061	37	.66776	.241220	.70890
8	.14405	.010206	.14228	38	.68922	.257694	.73330
7	.12545	.007757	.12410	39	.71106	.275062	.75825
6	.10704	.005660	.10608	40	.73327	.293378	.78377
5	.08883	.003906	.08816	41	.75589	.312700	.80990
4	.07078	.002485	.07035	42	.77894	.333091	.83668

γ = 0.17

φ	X	Y	T
43°	.80243	.354618	.86414
44	.82639	.377356	.89233
45	.85083	.401384	.92130
46	.87579	.426787	.95108
47	.90129	.453660	.98172
48	.92735	.482104	1.01329
49	.95400	.512229	1.04584
50	.98127	.544154	1.07943
51	1.00917	.578010	1.11413
52	1.03774	.613937	1.15001
53	1.06702	.652090	1.18714
54	1.09701	.692636	1.22561
55	1.12777	.735758	1.26551
56	1.15931	.781655	1.30693
57	1.19166	.830542	1.34999
58	1.22485	.882656	1.39479
59	1.25892	.938257	1.44146
60	1 29388	.997630	1 49014

γ = 0.18

φ	X	Y	T
50°	2.06533	1.54956	1.52292
49	1.83445	1.27881	1.42538
48	1.67800	1.10181	1.34657
47	1.55606	.96864	1.27830
46	1.45483	.86191	1.21724
45	1.36765	.77315	1.16160
44	1.29074	.69755	1.11023
43	1.22173	.63204	1.06239
42	1.15901	.57455	1.01751
41	1.10143	.52360	.97518
40	1.04814	.47807	.93508
39	.99850	.43714	.89693
38	.95199	.40014	.86052
37	.90821	.36653	.82568
36	.86683	.33591	.79224
35	.82757	.30789	.76009
34	.79020	.28221	.72910
33	.75452	.25859	.69918
32	.72038	.23684	.67023
31	.68763	.21676	.64219
30	.65614	.198209	.61498
29	.62580	.181040	.58854
28	.59651	.165136	.56281
27°	.56819	.150393	.53775
26	.54077	.136718	.51330
25	.51417	.124028	.48943
24	.48833	.112251	.46609
23	.46320	.101322	.44325
22	.43872	.091182	.42088
21	.41485	.081777	.39894
20	.39154	.073061	.37741
19	.36876	.064992	.35626
18	.34647	.057533	.33546
17	.32464	.050649	.31499
16	.30324	.044308	.29483
15	.28223	.038482	.27496
14	.26158	.033144	.25536
13	.24129	.028272	.23599
12	.22133	.023845	.21688
11	.20166	.019844	.19798
10	.18228	.016250	.17926
9	.16315	.013049	.16074
8	.14427	.010227	.14239
7	.12561	.007771	.12419
6	.10716	.005669	.10613
5	.08891	.003911	.08820
4	.07083	.002487	.07038
3	.05291	.001391	.05266
2	.03514	.000615	.03504
+1	.01751	.000153	.01749
	+	+	+
0	.00000	.000000	.00000
	−	+	−
−1°	.01740	.000152	.01743
2	.03470	.000604	.03481
3	.05192	.001356	.05216
4	.06906	.002405	.06949
5	.08614	.003749	.08681
6	.10317	.005388	.10413
7	.12016	.007324	.12146
8	.13712	.009557	.13882
9	.15406	.012088	.15620
10	.17099	.014921	.17363
11	.18792	.018058	.19111
12	.20486	.021506	.20866
13	.22182	.025266	.22628
14	.23881	.029345	.24400
15	.25584	.033752	.26181
16	.27293	.038491	.27972
17	.29009	.043572	.29777
18	.30731	.049003	.31595

γ = 0.4

φ	X	Y	T
52°	.86684	.481950	1.04647
53	.88747	.508840	1.07765
54	.90844	.537178	1.10981
55	.92975	.567061	1.14302
56	.95142	.598594	1.17736
57	.97346	.631891	1.21290
58	.99587	.667075	1.24971
59	1.01866	.704281	1.28789
60	1.04185	.743656	1.32753

γ = 0.5

φ	X	Y	T
29°	0.98413	.338743	.72106
28	.88201	.283238	.67306
27	.80260	.241866	.63110
26	.73635	.208903	.59316
25	.67940	.181643	.55818
24	.62877	.158557	.52552
23	.58309	.138689	.49473
22	.54135	.121390	.46551
21	.50280	.106200	.43763
20	.46691	.092779	.41092
19	.43328	.080866	.38521
18	.40158	.070258	.36041
17	.37157	.060791	.33641
16	.34303	.052335	.31314
15	.31579	.044778	.29051
14	.28971	.038031	.26847
13	.26466	.032017	.24697
12	.24055	.026670	.22596
11	.21728	.021935	.20539
10	.19478	.017764	.18524
9	.17298	.014114	.16546
8	.15181	.010950	.14603
7	.13123	.008240	.12691
6	.11118	.005955	.10808
5	.09163	.004071	.08953
4	.07253	.002567	.07121
3	.05385	.001424	.05312
2	.03555	.000625	.03523
+1	.01761	.000154	.01753
	+	+	+
0	.00000	.000000	.00000

γ = 0.5

φ	X	Y	T
1°	.01731	.000151	.01738
2	.03433	.000596	.03462
3	.05109	.001328	.05174
4	.06761	.002338	.06876
5	.08392	.003621	.08568
6	.10001	.005170	.10252
7	.11592	.006982	.11929
8	.13166	.009054	.13600
9	.14724	.011382	.15268
10	.16267	.013965	.16932
11	.17798	.016801	.18594
12	.19316	.019891	.20255
13	.20824	.023234	.21917
14	.22323	.026832	.23580
15	.23813	.030687	.25246
16	.25297	.034800	.26916
17	.26774	.039175	.28590
18	.28245	.043816	.30271
19	.29713	.048726	.31959
20	.31178	.053912	.33655
21	.32640	.059379	.35360
22	.34101	.065134	.37077
23	.35561	.071183	.38805
24	.37022	.077535	.40546
25	.38484	.084199	.42301
26	.39949	.091184	.44073
27	.41416	.098500	.45861
28	.42887	.106160	.47668
29	.44363	.114174	.49494
30	.45845	.122557	.51342
31	.47333	.131323	.53212
32	.48828	.140488	.55107
33	.50332	.150067	.57028
34	.51844	.160078	.58976
35	.53367	.170541	.60954
36	.54900	.181477	.62963
37	.56444	.192907	.65006
38	.58001	.204854	.67084
39	.59572	.217346	.69199
40	.61156	.230407	.71355
41	.62755	.244069	.73552
42	.64371	.258361	.75794
43	.66003	.273319	.78083
44	.67653	.288977	.80423
45	.69322	.305375	.82815
46	.71010	.322553	.85264
47	.72718	.340558	.87773
48	.74448	.359438	.90345

γ = 0.18			
φ	X	Y	T
19°	.32461	.054794	.33428
20	.34201	.060957	.35277
21	.35952	.067503	.37143
22	.37714	.074445	.39028
23	.39489	.081798	.40933
24	.41278	.089577	.42860
25	.43082	.097798	.44810
26	.44902	.106480	.46784
27	.46740	.115643	.48785
28	.48596	.125306	.50814
29	.50472	.135494	.52874
30	.52369	.146230	.54964
31	.54289	.157541	.57089
32	.56233	.169455	.59249
33	.58203	.182004	.61448
34	.60200	.195220	.63687
35	.62225	.209139	.65968
36	.64280	.223799	.68294
37	.66367	.239242	.70668
38	.68487	.255514	.73093
39	.70642	.272661	.75572
40	.72835	.290737	.78107
41	.75066	.309797	.80702
42	.77339	.329903	.83361
43	.79654	.351120	.86088
44	.82014	.373521	.88886
45	.84421	.397179	.91760
46	.86878	.422181	.94714
47	.89386	.448617	.97754
48	.91949	.476583	1.00884
49	.94567	.506186	1.04111
50	.97245	.537542	1.07440
51	.99984	.570776	1.10878
52	1.02788	.606023	1.14431
53	1.05658	.643431	1.18108
54	1.08597	.683162	1.21916
55	1.11609	.725390	1.25864
56	1.14695	.770306	1.29962
57	1.17859	.818118	1.34221
58	1.21104	.869053	1.38650
59	1.24431	.923360	1.43262
60	1.27844	.981309	1.48072

γ = 0.19			
φ	X	Y	T
49°	1.99111	1.43884	1.47035
48	1.77459	1.19374	1.37775
47	1.62516	1.03053	1.30220
46	1.50785	.90683	1.23648
45	1.41005	.80725	1.17754
44	1.32559	.72422	1.12372
43	1.25093	.65335	1.07396
42	1.18384	.59185	1.02754
41	1.12277	.53780	.98395
40	1.06665	.48986	.94279
39	1.01466	.44698	.90376
38	.96619	.40841	.86659
37	.92074	.37353	.83109
36	.87792	.34184	.79707
35	.83742	.31293	.76442
34	.79897	.28650	.73298
33	.76235	.26227	.70267
32	.72737	.23999	.67337
31	.69388	.21945	.64501
30	.66173	.200513	.61752
29	.63080	.183011	.59082
28	.60098	.166821	.56487
27	.57219	.151832	.53960
26	.54434	.137944	.51496
25	.51736	.125070	.49092
24	.49117	.113135	.46742
23	.46572	.102069	.44444
22	.44096	.091811	.42194
21	.41683	.082304	.39988
20	.39329	.073501	.37824
19	.37029	.065357	.35699
18	.34781	.057833	.33610
17	.32581	.050895	.31555
16	.30425	.044507	.29532
15	.28310	.038641	.27538
14	.26233	.033270	.25572
13	.24192	.028371	.23630
12	.22185	.023921	.21713
11	.20209	.019901	.19819
10	.18263	.016292	.17943
9	.16343	.013079	.16088
8	.14448	.010247	.14249
7	.12577	.007784	.12427
6	.10728	.005676	.10619
5	.08899	.003915	.08824
4	.07088	.002490	.07040

γ = 0.19

φ	X	Y	T
3°	.05294	.001392	.05268
2	.03516	.000615	.03504
+1	.01752	.000153	.01749
	+	+	+
0	.00000	.000000	.00000
	−	+	−
−1	.01740	.000152	.01743
2	0.3470	.000604	.03481
3	.05190	.001356	.05215
4	.06902	.002402	.06947
5	.08607	.003745	.08678
6	.10307	.005381	.10408
7	.12002	.007312	.12139
8	.13694	.009539	.13872
9	.15383	.012064	.15608
10	.17071	.014889	.17348
11	.18758	.018016	.19094
12	.20446	.021450	.20846
13	.22135	.025195	.22604
14	.23827	.029257	.24372
15	.25522	.033643	.26149
16	.27223	.038359	.27936
17	.28930	.043413	.29736
18	.30642	.048814	.31549
19	.32362	.054572	.33377
20	.34092	.060697	.35220
21	.35831	.067201	.37080
22	.37581	.074097	.38958
23	.39344	.081398	.40857
24	.41120	.089120	.42776
25	.42910	.097278	.44719
26	.44715	.105891	.46686
27	.46538	.114977	.48679
28	.48378	.124558	.50699
29	.50237	.134654	.52749
30	.52117	.145291	.54830
31	.54019	.156493	.56945
32	.55943	.168290	.59094
33	.57893	.180709	.61281
34	.59868	.193785	.63508
35	.61871	.207551	.65777
36	.63903	.222045	.68090
37	.65965	.237308	.70450
38	.68060	.253382	.72860
39	.70181	.270315	.75323
40	.72353	.288158	.77842
41	.74555	.306965	.80420
42	.76796	.326796	.83061

γ = 0.19

φ	X	Y	T
43°	.79078	.347714	.85768
44	.81404	.369788	.88546
45	.83776	.393092	.91398
46	.86194	.417708	.94329
47	.88663	.443723	.97345
48	.91183	.471231	1.00449
49	.93758	.500335	1.03649
50	.96389	.531146	1.06949
51	.99079	.563785	1.10355
52	1.01831	.598384	1.13876
53	1.04646	.635083	1.17518
54	1.07528	.674038	1.21289
55	1.10479	.715418	1.25197
56	1.13502	.759406	1.29253
57	1.16599	.806203	1.33466
58	1.19773	.856028	1.37846
59	1.23025	.909118	1.42407
60	1.26359	.965730	1.47160

γ = 0.20

φ	X	Y	T
48°	1.91475	1.33144	1.41840
47	1.71350	1.11151	1.33081
46	1.57159	.961847	1.25855
45	1.45917	.847381	1.19537
44	1.36498	.754766	1.13853
43	1.28336	.677277	1.08650
42	1.21103	.610979	1.03830
41	1.14590	.553344	.99328
40	1.08653	.502625	.95095
39	1.03190	.457578	.91093
38	.98123	.417263	.87294
37	.93394	.380962	.83673
36	.88956	.348113	.80210
35	.84771	.318258	.76891
34	.80810	.291027	.73700
33	.77047	.266113	.70627
32	.73460	.243260	.67660
31	.70032	.222250	.64791
30	.66748	.202899	.62012
29	.63593	.185048	.59316
28	.60557	.168559	.56697
27	.57628	.153312	.54148
26	.54799	.139203	.51665
25	.52061	.126139	.49243

	$\gamma = 0{,}18$		
φ	X	Y	T
19°	.32461	.054794	.33428
20	.34201	.060957	.35277
21	.35952	.067503	.37143
22	.37714	.074445	.39028
23	.39489	.081798	.40933
24	.41278	.089577	.42860
25	.43082	.097798	.44810
26	.44902	.106480	.46784
27	.46740	.115643	.48785
28	.48596	.125306	.50814
29	.50472	.135494	.52874
30	.52369	.146230	.54964
31	.54289	.157541	.57089
32	.56233	.169455	.59249
33	.58203	.182004	.61448
34	.60200	.195220	.63687
35	.62225	.209139	.65968
36	.64280	.223799	.68294
37	.66367	.239242	.70668
38	.68487	.255514	.73093
39	.70642	.272661	.75572
40	.72835	.290737	.78107
41	.75066	.309797	.80702
42	.77339	.329903	.83361
43	.79654	.351120	.86088
44	.82014	.373521	.88886
45	.84421	.397179	.91760
46	.86878	.422181	.94714
47	.89386	.448617	.97754
48	.91949	.476583	1.00884
49	.94567	.506186	1.04111
50	.97245	.537542	1.07440
51	.99984	.570776	1.10878
52	1.02788	.606023	1.14431
53	1.05658	.643431	1.18108
54	1.08597	.683162	1.21916
55	1.11609	.725390	1.25864
56	1.14695	.770306	1.29962
57	1.17859	.818118	1.34221
58	1.21104	.869053	1.38650
59	1.24431	.923360	1.43262
60	1.27844	.981309	1.48072

	$\gamma = 0{,}19$		
φ	X	Y	T
49°	1.99111	1.43884	1.47035
48	1.77459	1.19374	1.37775
47	1.62516	1.03053	1.30220
46	1.50785	.90683	1.23648
45	1.41005	.80725	1.17754
44	1.32559	.72422	1.12372
43	1.25093	.65335	1.07396
42	1.18384	.59185	1.02754
41	1.12277	.53780	.98395
40	1.06665	.48986	.94279
39	1.01466	.44698	.90376
38	.96619	.40841	.86659
37	.92074	.37353	.83109
36	.87792	.34184	.79707
35	.83742	.31293	.76442
34	.79897	.28650	.73298
33	.76235	.26227	.70267
32	.72737	.23999	.67337
31	.69388	.21945	.64501
30	.66173	.200513	.61752
29	.63080	.183011	.59082
28	.60098	.166821	.56487
27	.57219	.151832	.53960
26	.54434	.137944	.51496
25	.51736	.125070	.49092
24	.49117	.113135	.46742
23	.46572	.102069	.44444
22	.44096	.091811	.42194
21	.41683	.082304	.39988
20	.39329	.073501	.37824
19	.37029	.065357	.35699
18	.34781	.057833	.33610
17	.32581	.050895	.31555
16	.30425	.044507	.29532
15	.28310	.038641	.27538
14	.26233	.033270	.25572
13	.24192	.028371	.23630
12	.22185	.023921	.21713
11	.20209	.019901	.19819
10	.18263	.016292	.17943
9	.16343	.013079	.16088
8	.14448	.010247	.14249
7	.12577	.007784	.12427
6	.10728	.005676	.10619
5	.08899	.003915	.08824
4	.07088	.002490	.07040

γ = 0,19			
φ	X	Y	T
3°	.05294	.001392	.05268
2	.03516	.000615	.03504
+1	.01752	.000153	.01749
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01740	.000152	.01743
2	0.3470	.000604	.03481
3	.05190	.001356	.05215
4	.06902	.002402	.06947
5	.08607	.003745	.08678
6	.10307	.005381	.10408
7	.12002	.007312	.12139
8	.13694	.009539	.13872
9	.15383	.012064	.15608
10	.17071	.014889	.17348
11	.18758	.018016	.19094
12	.20446	.021450	.20846
13	.22135	.025195	.22604
14	.23827	.029257	.24372
15	.25522	.033643	.26149
16	.27223	.038359	.27936
17	.28930	.043413	.29736
18	.30642	.048814	.31549
19	.32362	.054572	.33377
20	.34092	.060697	.35220
21	.35831	.067201	.37080
22	.37581	.074097	.38958
23	.39344	.081398	.40857
24	.41120	.089120	.42776
25	.42910	.097278	.44719
26	.44715	.105891	.46686
27	.46538	.114977	.48679
28	.48378	.124558	.50699
29	.50237	.134654	'52749
30	.52117	.145291	.54830
31	.54019	.156493	.56945
32	.55943	.168290	.59094
33	.57893	.180709	.61281
34	.59868	.193785	.63508
35	.61871	.207551	.65777
36	.63903	.222045	.68090
37	.65965	.237308	.70450
38	.68060	.253382	.72860
39	.70181	.270315	.75323
40	.72353	.288158	.77842
41	.74555	.306965	.80420
42	.76796	.326796	.83061

γ = 0,19			
φ	X	Y	T
43°	.79078	.347714	.85768
44	.81404	.369788	.88546
45	.83776	.393092	.91398
46	.86194	.417708	.94329
47	.88663	.443723	.97345
48	.91183	.471231	1.00449
49	.93758	.500335	1.03649
50	.96389	.531146	1.06949
51	.99079	.563785	1.10355
52	1.01831	.598384	1.13876
53	1.04646	.635083	1.17518
54	1.07528	.674038	1.21289
55	1.10479	.715418	1.25197
56	1.13502	.759406	1.29253
57	1.16599	.806203	1.33466
58	1.19773	.856028	1.37846
59	1.23025	.909118	1.42407
60	1.26359	.965730	1.47160

γ = 0.20			
φ	X	Y	T
48°	1.91475	1.33144	1.41840
47	1.71350	1.11151	1.33081
46	1.57159	.961847	1.25855
45	1.45917	.847381	1.19537
44	1.36498	.754766	1.13853
43	1.28336	.677277	1.08650
42	1.21103	.610979	1.03830
41	1.14590	.553344	.99328
40	1.08653	.502625	.95095
39	1.03190	.457578	.91093
38	.98123	.417263	.87294
37	.93394	.380962	.83673
36	.88956	.348113	.80210
35	.84771	.318258	.76891
34	.80810	.291027	.73700
33	.77047	.266113	.70627
32	.73460	.243260	.67660
31	.70032	.222250	.64791
30	.66748	.202899	.62012
29	.63593	.185048	.59316
28	.60557	.168559	.56697
27	.57628	.153312	.54148
26	.54799	.139203	.51665
25	.52061	.126139	.49243

γ = 0.2			
φ	X	Y	T
24°	.49406	.114040	.46877
23	.46829	.102832	.44564
22	.44323	.092451	.42301
21	.41884	.082840	.40083
20	.39506	.073948	.37908
19	.37185	.065728	.35773
18	.34917	.058139	.33675
17	.32698	.051144	.31612
16	.30526	.044708	.29581
15	.28397	.038802	.27580
14	.26307	.033397	.25608
13	.24255	.028470	.23661
12	.22238	.023997	.21739
11	.20253	.019958	.19840
10	.18298	.016334	.17961
9	.16371	.013109	.16102
8	.14470	.010268	.14260
7	.12594	.007798	.12435
6	.10740	.005685	.10625
5	.08907	.003920	.08828
4	.07093	.002492	.07043
3	.05297	.001393	.05269
2	.03517	.000615	.03505
+1	.01752	.000153	.01749
	+	+	+
0	.00000	.000800	.00000
	—	+	—
−1	.01740	.000152	.01743
2	.03468	.000604	.03480
3	.05187	.001355	.05214
4	.06897	.002400	.06945
5	.08600	.003741	.08674
6	.10297	.005374	.10403
7	.11988	.007301	.12132
8	.13676	.009523	.13863
9	.15360	.012040	.15597
10	.17042	.014856	.17334
11	.18724	.017972	.19076
12	.20406	.021394	.20825
13	.22088	.025124	.22580
14	.23773	.029169	.24344
15	.25461	.033535	.26117
16	.27153	.038228	.27900
17	.28851	.043256	.29695
18	.30554	.048628	.31503
19	.32264	.054352	.33325
20	.33983	.060440	.35163
21	.35712	.066903	.37017

γ = 0.2			
φ	X	Y	T
22°	.37450	.073753	.38890
23	.39201	.081003	.40782
24	.40963	.088669	.42694
25	.42740	.096766	.44629
26	.44531	.105311	.46589
27	.46339	.114323	.48573
28	.48163	.123822	.50585
29	.50006	.133830	.52626
30	.51869	.144370	.54698
31	.53753	.155466	.56802
32	.55659	.167147	.58941
33	.57589	.179441	.61117
34	.59543	.192380	.63332
35	.61524	.205997	.65589
36	.63534	.220330	.67889
37	.65572	.235417	.70236
38	.77642	.251300	.72631
39	.69745	.268026	.75079
40	.71882	.285644	.77582
41	.74055	.304206	.80143
42	.76266	.323771	.82766
43	.78517	.344399	.85455
44	.80810	.366159	.88213
45	.83146	.389121	.91044
46	.85528	.813365	.93953
47	.87959	.438974	.96945
48	.90439	.466041	1.00025
49	.92971	.494666	1.03198
50	.95557	.524955	1.06469
51	.98201	.557024	1.09846
52	1.00903	.591001	1.13335
53	1.03667	.627024	1.16943
54	1.06494	.665241	1.20678
55	1.09388	.705815	1.24548
56	1.12350	.748922	1.28563
57	1.15383	.794754	1.32732
58	1.18489	.843521	1.37066
59	1.21671	.895452	1.41576
60	1.24931	.950797	1.46276

γ = 0.3			
φ	X	Y	T
40°	1.47905	.776117	1.08479
39	1.33120	.654103	1.01903
38	1.22128	.566599	.96308
37	1.13198	.498037	.91333

$\gamma = 0.3$			
φ	X	Y	T
36°	1.05597	.441769	.86803
35	.98937	.394244	.82615
34	.92984	.353312	.78704
33	.87584	.317563	.75023
32	.82632	.286000	.71537
31	.78049	.257908	.68220
30	.73777	.232740	.65051
29	.69772	.210072	.62013
28	.65996	.189569	.59092
27	.62422	.170959	.56276
26	.59026	.154020	.53556
25	.55787	.138568	.50922
24	.52689	.124448	.48366
23	.49718	.111527	.45883
22	.46862	.099695	.43466
21	.44110	.088852	.41111
20	.41453	.078915	.38811
19	.38882	.069810	.36564
18	.36390	.061472	.34365
17	.33972	.053845	.32211
16	.31620	.046879	.30098
15	.29331	.040529	.28024
14	.27099	.034755	.25985
13	.24920	.029523	.23980
12	.22790	.024800	.22005
11	.20706	.020559	.20058
10	.18663	.016773	.18138
9	.16661	.013421	.16243
8	.14694	.010482	.14370
7	.12762	.007937	.12517
6	.10861	.005771	.10684
5	.08989	.003968	.08868
4	.07145	.002516	.07068
3	.05326	.001403	.05283
2	.03529	.000618	.03511
+1	0.1755	.000153	.01750
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01736	.000151	.01741
2	.03456	.000601	.03474
3	.05161	.001345	.05200
4	.06851	.002379	.06921
5	.08529	.003699	.08638
6	.10195	.005304	.10351
7	.11851	.007191	.12062
8	.13498	.009359	.13772
9	.15138	.011809	.15483

$\gamma = 0.3$			
φ	X	Y	T
10°	.16770	.014542	.17194
11	.18398	.017557	.18908
12	.20020	.020858	.20826
13	.21639	.024448	.22347
14	.23256	.028329	.24075
15	.24871	.032506	.25809
16	.26485	.036984	.27551
17	.28100	.041768	.29302
18	.29717	0.46866	.31064
19	.31336	.052284	.32836
20	.32958	.058029	.34622
21	.34585	.064112	.36421
22	.36218	.070542	.38235
23	.37856	.077330	.40065
24	.39502	.084486	.41914
25	.41156	0.92025	.43781
26	.42819	.099959	.45669
27	.44493	.108304	.47579
28	.46178	.117075	.49512
29	.47875	.126290	.51470
30	.49585	.135967	.53455
31	.51310	.146127	.55469
32	.53050	.156791	.57513
33	.54807	.167983	.59589
34	.56581	.179727	.61699
35	.58374	.192050	.63846
36	.60187	.204982	.66031
37	.62020	.218553	.68257
38	.63876	.232796	.70525
39	.65756	.247748	.72840
40	.67660	.263447	.75203
41	.69590	.279935	.77616
42	.71548	.297255	.80085
43	.73534	.315457	.02610
44	.75550	.334591	.85196
45	.77597	.354713	.87847
46	.79678	.375883	.90565
47	.81792	.398164	.93356
48	.83942	.421628	.96224
49	.86129	.446352	.99172
50	.88355	.472413	1.02207
51	.90620	.499900	1.05334
52	.92928	.528908	1.08557
53	.95278	.559539	1.11885
54	.97672	.591904	1.15322
55	1.00113	.626124	1.18876
56	1.02601	.662329	1.22556
57	1.05137	.700659	1.26368

γ = 0,5			
φ	X	Y	T
49	.76000	.379044	[illegible]
50	.77425	.400032	[illegible]
51	.78775	.421800	.98481
52	.80100	.444706	1.01348
53	[illegible]	.468000	1.04300
54	[illegible]	.490077	1.07349
55	[illegible]	.520078	1.10482
56	[illegible]	.540009	1.13725
57	[illegible]	.578048	1.17076
58	[illegible]	.600006	1.20548
59	[illegible]	.623178	1.24144
60	[illegible]	.657840	1.27875

γ = 2,6			
φ	X	Y	T
26	.93244	.296752	.65330
25	.82202	.234797	.60259
24	.72613	.193594	.55987
23	.65774	.159763	.52220
22	.60999	.139873	.48766
21	.54672	.120048	.45602
20	.50454	.103259	.42604
19	.45422	.088847	.39788
18	.42083	.076552	.37096
17	.39225	.065444	.34520
16	.35997	.055877	.32044
15	.32993	.047462	.29657
14	.30098	.040049	.27342
13	.27378	.033518	.25101
12	.24787	.027773	.22928
11	.22310	.022731	.20806
10	.19934	.018347	.18735
9	.17649	.014504	.16711
8	.15440	.011208	.14718
7	.13317	.008405	.12783
6	.11255	.006053	.10874
5	.09234	.004125	.08997
4	.07309	.002594	.07148
3	.05415	.001435	.05327
2	.03568	.000628	.03530
1	.01764	.000155	.01755
	+	+	+
	.00000	.000000	.00000

γ = 0,6			
φ	X	Y	T
1	.01728	.000150	.01736
2	.03421	.000593	.03456
3	.05084	.001319	.05162
4	.06718	.002318	.06854
5	.08326	.003583	.08534
6	.09909	.005107	.10204
7	.11469	.006885	.11865
8	.13009	.008911	.13518
9	.14530	.011184	.15166
10	.16033	.013699	.16808
11	.17520	.016456	.18446
12	.18993	.019452	.20083
13	.20452	.022687	.21717
14	.21899	.026161	.23352
15	.23336	.029876	.24987
16	.24765	.033833	.26625
17	.26181	.038034	.28266
18	.27592	.042483	.29911
19	.28996	.047181	.31562
20	.30395	.052135	.33219
21	.31789	.057348	.34885
22	.33180	.062826	.36559
23	.34568	.068575	.38244
24	.35954	.074602	.39940
25	.37339	.080915	.41649
26	.38724	.087522	.43372
27	.40110	.094432	.45109
28	.41498	.101655	.46864
29	.42887	.109202	.48636
30	.44280	.117084	.50428
31	.45677	.125314	.52240
32	.47079	.133905	.54075
33	.48487	.142872	.55933
34	.49901	.152230	.57817
35	.51322	.161997	.59728
36	.52751	.172191	.61668
37	.54188	.182830	.63638
38	.55635	.193936	.65642
39	.57093	.205531	.67680
40	.58562	.217638	.69755
41	.60042	.230284	.71869
42	.61535	.243495	.74024
43	.63042	.257303	.76224
44	.64563	.271737	.78470
45	.66094	.286833	.80766
46	.67651	.302626	.83114
47	.69219	.319156	.85518
48	.70805	.336465	.87981

$\gamma = 0.4$

φ	X	Y	T
52°	.86684	.481950	1.04647
53	.88747	.508840	1.07765
54	.90844	.537178	1.10981
55	.92975	.567061	1.14302
56	.95142	.598594	1.17736
57	.97346	.631891	1.21290
58	.99587	.667075	1.24971
59	1.01866	.704281	1.28789
60	1.04185	.743656	1.32753

$\gamma = 0.5$

φ	X	Y	T
29°	0.98413	.338743	.72106
28	.88201	.283238	.67306
27	.80260	.241866	.63110
26	.73635	.208903	.59316
25	.67940	.181643	.55818
24	.62877	.158557	.52552
23	.58309	.138689	.49473
22	.54135	.121390	.46551
21	.50280	.106200	.43763
20	.46691	.092779	.41092
19	.43328	.080866	.38521
18	.40158	.070258	.36041
17	.37157	.060791	.33641
16	.34303	.052335	.31314
15	.31579	.044778	.29051
14	.28971	.038031	.26847
13	.26466	.032017	.24697
12	.24055	.026670	.22596
11	.21728	.021935	.20539
10	.19478	.017764	.18524
9	.17298	.014114	.16546
8	.15181	.010950	.14603
7	.13123	.008240	.12691
6	.11118	.005955	.10808
5	.09163	.004071	.08953
4	.07253	.002567	.07121
3	.05385	.001424	.05312
2	.03555	.000625	.03523
+1	.01761	.000154	.01753
	+	+	+
0	.00000	.000000	.00000

$\gamma = 0.5$

φ	X	Y	T
1°	.01731	.000151	.01738
2	.03433	.000596	.03462
3	.05109	.001328	.05174
4	.06761	.002338	.06876
5	.08392	.003621	.08568
6	.10001	.005170	.10252
7	.11592	.006982	.11929
8	.13166	.009054	.13600
9	.14724	.011382	.15268
10	.16267	.013965	.16932
11	.17798	.016801	.18594
12	.19316	.019891	.20255
13	.20824	.023234	.21917
14	.22323	.026832	.23580
15	.23813	.030687	.25246
16	.25297	.034800	.26916
17	.26774	.039175	.28590
18	.28245	.043816	.30271
19	.29713	.048726	.31959
20	.31178	.053912	.33655
21	.32640	.059379	.35360
22	.34101	.065134	.37077
23	.35561	.071183	.38805
24	.37022	.077535	.40546
25	.38484	.084199	.42301
26	.39949	.091184	.44073
27	.41416	.098500	.45861
28	.42887	.106160	.47668
29	.44363	.114174	.49494
30	.45845	.122557	.51342
31	.47333	.131323	.53212
32	.48828	.140488	.55107
33	.50332	.150067	.57028
34	.51844	.160078	.58976
35	.53367	.170541	.60954
36	.54900	.181477	.62963
37	.56444	.192907	.65006
38	.58001	.204854	.67084
39	.59572	.217346	.69199
40	.61156	.230407	.71355
41	.62755	.244069	.73552
42	.64371	.258361	.75794
43	.66003	.273319	.78083
44	.67653	.288977	.80423
45	.69322	.305375	.82815
46	.71010	.322553	.85264
47	.72718	.340558	.87773
48	.74448	.359438	.90345

[illegible]	[illegible]	[illegible]	T
[illegible]	[illegible]	[illegible]	.21573
[illegible]	[illegible]	[illegible]	.21808
[illegible]	[illegible]	[illegible]	.22158
[illegible]	[illegible]	[illegible]	.22343
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[illegible]	[illegible]	[illegible]	.24507
[illegible]	[illegible]	[illegible]	.26087
[illegible]	[illegible]	[illegible]	.27668
[illegible]	[illegible]	[illegible]	.29251
[illegible]	[illegible]	[illegible]	.30836
[illegible]	[illegible]	[illegible]	.32426
[illegible]	[illegible]	[illegible]	.34022
[illegible]	[illegible]	[illegible]	.35624
[illegible]	[illegible]	[illegible]	.37233
[illegible]	[illegible]	[illegible]	.38852
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[illegible]	[illegible]	[illegible]	.42119
[illegible]	[illegible]	[illegible]	.43771
[illegible]	[illegible]	[illegible]	.45437
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[illegible]	[illegible]	[illegible]	.48815
[illegible]	[illegible]	[illegible]	.50530
[illegible]	[illegible]	[illegible]	.52263
[illegible]	[illegible]	[illegible]	.54018
[illegible]	[illegible]	[illegible]	.55794
[illegible]	[illegible]	[illegible]	.57594
[illegible]	[illegible]	[illegible]	.59420
[illegible]	[illegible]	[illegible]	.61272
[illegible]	[illegible]	[illegible]	.63154
[illegible]	[illegible]	[illegible]	.65065
[illegible]	[illegible]	[illegible]	.67010
[illegible]	[illegible]	[illegible]	.68989
[illegible]	[illegible]	[illegible]	.71005
[illegible]	[illegible]	[illegible]	.73060
[illegible]	[illegible]	[illegible]	.75156
[illegible]	[illegible]	[illegible]	.77297
[illegible]	[illegible]	[illegible]	.79484
[illegible]	[illegible]	[illegible]	.81721
[illegible]	[illegible]	[illegible]	.84011
[illegible]	[illegible]	[illegible]	.86357
[illegible]	[illegible]	[illegible]	.88762
[illegible]	[illegible]	[illegible]	.91230
[illegible]	[illegible]	.317408	.93765
[illegible]	[illegible]	.380221	.96372
[illegible]	[illegible]	.405908	.99055
[illegible]	[illegible]	.426617	1,01818
[illegible]	[illegible]	.448342	1,04668
[illegible]	[illegible]	.471171	1,07611

$\gamma = 0.6$

φ	X	Y	T
49°	.72409	.354598	.90506
50	.74032	.373604	.93098
51	.75675	.393535	.95760
52	.77339	.414449	.98497
53	.79023	.436408	1.01314
54	.80730	.459477	1.04216
55	.82460	.483727	1.07208
56	.84213	.509237	1.10297
57	.85990	.536090	1.13488
58	.87792	.564378	1.16789
59	.89619	.594199	1.20207
60	.91472	.625663	1.23751

$\gamma = 0.7$

φ	X	Y	T
23°	.81319	.220114	.56922
22	.70121	.173643	.52145
21	.62208	.142434	.48153
20	.55903	.118842	.44613
19	.50586	.099998	.41382
18	.45945	.084464	.38381
17	.41804	.071399	.35562
16	.38047	.060267	.32892
15	.34598	.050697	.30346
14	.31401	.042424	.27906
13	.28414	.035250	.25558
12	.25606	.029022	.23291
11	.22951	.023619	.21094
10	.20430	.018945	.18961
9	.18027	.014921	.16885
8	.15728	.011483	.14859
7	.13521	.008577	.12880
6	.11397	.006156	.10942
5	.09348	.004182	.09042
4	.07366	.002621	.07176
3	.05446	.001446	.05342
2	.03581	.000631	.03536
+1	.01767	.000155	.01756
	+	+	+
0	.00000	.000000	.00000
	−	+	−
−1	.01725	.000150	.01735
2	.03410	.000591	.03451
3	.05059	.001310	.05149

$\gamma = 0.7$

φ	X	Y	T
4°	.06676	.002299	.06832
5	.08262	.003546	.08500
6	.09819	.005045	.10157
7	.11351	.006790	.11802
8	.12859	.008775	.13439
9	.14344	.010996	.15067
10	.15810	.013448	.16688
11	.17257	.016129	.18305
12	.18687	.019038	.19917
13	.20101	.022174	.21526
14	.21501	.025535	.23134
15	.22888	.029123	.24741
16	.24264	.032938	.26349
17	.25629	.036981	.27959
18	.26985	.041255	.29572
19	.28332	.045763	.31189
20	.29672	.050509	.32811
21	.31006	.055495	.34440
22	.32334	.060728	.36076
23	.33658	.066211	.37722
24	.34978	.071952	.39377
25	.36296	.077958	.41044
26	.37612	.084234	.42723
27	.38927	.090790	.44415
28	.40241	.097634	.46123
29	.41557	.104776	.47847
30	.42873	.112225	.49589
31	.44192	.119994	.51350
32	.45514	.128094	.53131
33	.46839	.136539	.54935
34	.48169	.145341	.56762
35	.49504	.154518	.58614
36	.50845	.164083	.60494
37	.52193	.174056	.62401
38	.53548	.184453	.64340
39	.54911	.195297	.66311
40	.56283	.206607	.68316
41	.57664	.218407	.70359
42	.59056	.230721	.72440
43	.60459	.243577	.74562
44	.61874	.257001	.76728
45	.63301	.271025	.78941
46	.64741	.285682	.81203
47	.66195	.301005	.83517
48	.67663	.317034	.85887
49	.69147	.333809	.88316
50	.70647	.351373	.90807
51	.72164	.369773	.93365

γ = 0.7

φ	X	Y	T
52°	.73698	.389060	.95994
53	.75250	.409288	.98698
54	.76821	.430517	1.01481
55	.78411	.452812	1.04350
56	.80021	.476241	1.07310
57	.81651	.500878	1.10366
58	.83303	.526806	1.13527
59	.84976	.554113	1.16797
60	.86671	.582897	1.20187

γ = 0.8

φ	X	Y	T
20°	.65361	.147646	.47637
19	.56945	.117797	.43575
18	.50514	.096255	.40043
17	.45205	.079501	.36852
16	.40632	.065947	.33906
15	.36587	.054722	.31149
14	.32942	.045287	.28544
13	.29609	.037282	.26064
12	.26531	.030454	.23690
11	.23663	.024617	.21407
10	.20973	.019628	.19203
9	.18435	.015379	.17069
8	.16028	.011780	.14997
7	.13737	.008761	.12980
6	.11546	.006264	.11012
5	.09446	.004240	.09088
4	.07426	.002649	.07205
3	.05478	.001457	.05357
2	.03595	.000634	.03543
+1	.01771	.000155	.01758
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01722	.000150	.01734
2	.03399	.000588	.03445
3	.05035	.001302	.05137
4	.06634	.002279	.06810
5	.08199	.003510	.08468
6	.09732	.004986	.10111
7	.11236	.006699	.11742
8	.12713	.008644	.13361
9	.14166	.010815	.14971

γ = 0.8

φ	X	Y	T
10°	.15596	.013207	.16573
11	.17005	.015819	.18168
12	.18395	.018647	.19758
13	.19768	.021690	.21343
14	.21125	.024947	.22926
15	.22467	.028418	.24507
16	.23795	.032103	.26087
17	.25112	.036002	.27668
18	.26418	.040119	.29251
19	.27713	.044454	.30836
20	.29000	.049012	.32426
21	.30280	.053795	.34022
22	.31552	.058808	.35624
23	.32819	.064055	.37233
24	.34081	.069541	.38851
25	.35339	.075274	.40480
26	.36593	.081258	.42119
27	.37846	.087501	.43771
28	.39096	.094012	.45437
29	.40346	.100799	.47118
30	.41596	.107871	.48815
31	.42847	.115238	.50530
32	.44099	.122912	.52263
33	.45353	.130904	.54018
34	.46611	.139227	.55794
35	.47872	.147894	.57594
36	.49137	.156920	.59420
37	.50408	.166321	.61272
38	.51684	.176114	.63154
39	.52967	.186317	.65065
40	.54256	.196950	.67010
41	.55554	.208032	.68989
42	.56860	.219588	.71005
43	.58175	.231640	.73060
44	.59500	.244215	.75156
45	.60836	.257340	.77297
46	.62182	.271045	.79484
47	.63541	.285361	.81721
48	.64911	.300323	.84011
49	.66295	.315968	.86357
50	.67693	.332335	.88762
51	.69105	.349466	.91230
52	.70532	.367408	.93765
53	.71975	.386211	.96372
54	.73434	.405928	.99055
55	.74903	.426617	1.01818
56	.76402	.448342	1.04668
57	.77913	.471171	1.07611

γ = 0.8

φ	X	Y	T
58°	.79442	.495177	1.10652
59	.80990	.520441	1.13798
60	.82557	.547052	1.17057

γ = 0.9

φ	X	Y	T
18°	.58115	.116911	.42469
17	.50159	.091787	.38566
16	.44103	.073825	.35177
15	.39111	.059967	.32114
14	.34815	.048848	.29286
13	.31016	.039721	.26638
12	.27592	.032124	.24134
11	.24462	.025753	.21749
10	.21571	.020391	.19464
9	.18878	.015880	.17266
8	.16350	.012100	.15142
7	.13964	.008958	.13084
6	.11702	.006378	.11084
5	.09547	.004301	.09136
4	.07486	.002678	.07234
3	.05510	.001468	.05373
2	.03608	.000637	.03549
+1	.01774	.000156	.01760
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01719	.000149	.01732
2	.03388	.000586	.03439
3	.05011	.001294	.05124
4	.06593	.002261	.06789
5	.08137	.003476	.08436
6	.09647	.004929	.10067
7	.11125	.006612	.11683
8	.12573	.008518	.13287
9	.13994	.010642	.14879
10	.15391	.012979	.16462
11	.16765	.015525	.18037
12	.18118	.018278	.19605
13	.19452	.021235	.21168
14	.20769	.024395	.22727
15	.22069	.027758	.24283
16	.23354	.031323	.25837
17	.24627	.035091	.27392
18	.25887	.039064	.28946
19°	.27136	.043242	.30503
20	.28375	.047630	.32063
21	.29605	.052229	.33628
22	.30827	.057044	.35198
23	.32043	.062078	.36774
24	.33252	.067337	.38359
25	.34456	.072825	.39952
26	.35656	.078549	.41555
27	.36853	.084515	.43170
28	.38047	.090731	.44797
29	.39239	.097204	.46439
30	.40430	.103943	.48095
31	.41621	.110957	.49768
32	.42812	.118256	.51460
33	.44004	.125851	.53170
34	.45198	.133754	.54901
35	.46395	.141977	.56655
36	.47595	.150534	.58432
37	.48798	.159440	.60235
38	.50006	.168709	.62065
39	.51219	.178358	.63924
40	.52438	.188406	.65815
41	.53663	.198872	.67738
42	.54896	.209775	.69696
43	.56136	.221139	.71692
44	.57384	.232987	.73727
45	.58642	.245343	.75804
46	.59908	.258236	.77925
47	.61185	.271695	.80094
48	.62473	.285751	.82313
49	.63773	.300438	.84586
50	.65084	.315792	.86916
51	.66408	.331853	.89306
52	.67745	.348663	.91760
53	.69096	.366268	.94282
54	.70461	.384717	.96877
55	.71840	.404062	.99550
56	.73235	.424362	1.02305
57	.74646	.445681	1.05148
58	.76073	.468086	1.08086
59	.77517	.491651	1.11124
60	.78978	.516458	1.14271

γ = 1.0			
φ	X	Y	T
17°	.59414	.116140	.41265
16	.49357	086268	.36907
15	.42541	.067336	.33331
14	.37195	.053493	.30177
13	.32720	.042738	.27303
12	.28832	.034111	.24635
11	.25371	.027063	.22127
10	.22236	.021249	.19749
9	.19361	.016433	.17477
8	.16696	.012447	.15297
7	.14206	.009167	.13194
6	.11865	.006498	.11160
5	.09652	.004365	.09185
4	.07549	.002708	.07263
3	.05543	.001480	.05389
2	.03622	.000640	.03556
+1	.01777	.000156	.01761
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01716	.000149	.01731
2	.03377	.000583	.03434
3	.04988	.001286	.05112
4	.06554	.002243	.06768
5	.08078	.003442	.08405
6	.09565	.004873	.10023
7	.11017	.006527	.11625
8	.12438	.008397	.13214
9	.13830	.010477	.14790
10	.15195	.012762	.16355
11	.16536	.015246	.17910
12	.17854	.017928	.19458
13	.19152	.020805	.21000
14	.20431	.023876	.22537
15	.21693	.027138	.24069
16	.22938	.030593	.25600
17	.24170	.034240	.27129
18	.25388	.038081	.28657
19	.26594	.042117	.30187
20	.27789	.046349	.31720
21	.28975	.050781	.33255
22	.30151	.055416	.34796
23	.31320	.060258	.36342
24	.32482	.065311	.37895
25	.33639	.070580	.39456
26	.34790	.076070	.41026
27	.35936	.081788	.42607

γ = 1.0			
φ	X	Y	T
28″	.37080	.087740	.44199
29	.38220	.093933	.45805
30	.39359	.100375	.47425
31	.40496	.107075	.49060
32	.41633	.114043	.50712
33	.42770	.121287	.52383
34	.43908	.128820	.54073
35	.45048	.136652	.55784
36	.46190	.144797	.57518
37	.47334	.153267	.59276
38	.48482	.162077	.61061
39	.49635	.171242	.62873
40	.50791	.180780	.64714
41	.51954	.190708	.66588
42	.53122	.201044	.68494
43	.54297	.211810	.70436
44	.55479	.223027	.72417
45	.56669	.234719	.74437
46	.57867	.246911	.76500
47	.59074	.259631	.78609
48	.60290	.272908	.80766
49	.61517	.286772	.82974
50	.62754	.301258	.85236
51	.64002	.316402	.87557
52	.65262	.332243	.89939
53	.66534	.348823	.92387
54	.67819	.366188	.94905
55	.69117	.384389	.97497
56	.70429	.403479	1.00169
57	.71755	.423515	1.02926
58	.73095	.444561	1.05773
59	.74451	.466686	1.08717
60	.75822	.489965	1.11765

γ = 1.1			
φ	X	Y	T
15°	.47885	.079331	.35022
14	.40438	.060032	.31302
13	.34871	.046645	.28098
12	.30320	.036544	.25212
11	.26422	.028605	.22551
10	.22985	.022228	.20060
9	.19892	.017049	.17704
8	.17069	.012826	.15460
7	.14463	.009392	.13309

$\gamma = 1.1$

φ	X	Y	T
6°	.12037	.006625	.11238
5	.09761	.004432	.09236
4	.07613	.002739	.07294
3	.05576	.001492	.05405
2	.03636	.000643	.03563
+1	.01780	.000156	.01763
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01713	.000149	.01729
2	.03366	.000580	.03428
3	.04965	.001278	.05100
4	.06515	.002225	.06748
5	.08020	.003409	08374
6	.09485	.004819	.09980
7	.10913	.006446	.11569
8	.12308	.008281	.13143
9	.13671	.010319	.14703
10	.15007	.012554	.16251
11	.16317	.014981	.17788
12	.17602	.017596	.19317
13	.18867	.020398	.20839
14	.20111	.023385	.22354
15	.21337	.026555	.23865
16	.22546	.029907	.25372
17	.23739	.033443	.26878
18	.24919	.037162	.28382
19	.26086	.041066	.29887
20	.27241	.045156	.31393
21	.28385	.049436	.32903
22	.29521	.053907	.34415
23	.30647	.058574	.35933
24	.31767	.063441	.37457
25	.32879	.068511	.38989
26	.33986	.073790	.40528
27	.35088	.079283	.42078
28	.36185	.084998	.43638
29	.37280	.090939	.45211
30	.38371	.097116	.46797
31	.39461	.103535	.48397
32	.40550	.110206	.50014
33	.41638	.117138	.51648
34	.42726	.124340	.53301
35	.43815	.131825	.54973
36	.44905	.139603	.56668
37	.45998	.147688	.58386
38	.47093	.156092	.60128
39	.48191	.164829	.61898
40°	.49293	.173917	.63695
41	.50400	.183370	.65523
42	.51512	.193208	.67383
43	.52630	.203449	.69277
44	.53753	.214114	.71208
45	.54884	.225224	.73178

$\gamma = 1.2$

φ	X	Y	T
14°	.45528	.070755	.32871
13	.37770	.052079	.29093
12	.32169	.039641	.25892
11	.27662	.030459	.23031
10	.23836	.023359	.20403
9	.20481	.017738	.17950
8	.17474	.013240	.15635
7	.14738	.009634	.13431
6	.12218	.006760	.11320
5	.09874	.004501	.09288
4	.07679	.002772	.07325
3	.05610	.001504	.05421
2	.03650	.000647	.03570
+1	.01783	.000157	.01764
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01710	.000148	.01728
2	.03355	.000578	.03423
3	.04942	.001270	.05088
4	.06476	.002208	.06728
5	.07963	.003377	.08344
6	.09407	.004767	.09939
7	.10812	.006367	.11515
8	.12181	.008169	.13074
9	.13518	.010167	.14618
10	.14826	.012354	.16150
11	.16106	.014727	.17670
12	.17361	.017280	.19181
13	.18593	.020012	.20683
14	.19805	.022921	.22178
15	.20997	.026004	.23668
16	.22172	.029262	.25154
17	.23331	.032694	.26637
18	.24474	.036300	.28119

γ = 1.2			
φ	X	Y	T
19°	.25605	.040083	.29600
20	.26723	.044043	.31082
21	.27830	.048182	.32566
22	.28927	.052504	.34054
23	.30015	.057011	.35545
24	.31095	.061706	.37042
25	.32168	.066595	.38546
26	.33235	.071682	.40058
27	.34296	.076973	.41578
28	.35352	.082472	.43109
29	.36404	.088186	.44651
30	.37454	.094123	.46206
31	.38501	.100289	.47775
32	.39546	.106693	.49359
33	.40589	.113343	.50959
34	.41633	.120250	.52577
35	.42677	.127423	.54215
36	.43721	.134874	.55874
37	.44767	.142614	.57554
38	.45815	.150655	.59259
39	.46866	.159012	.60989
40	.47919	.167699	.62747
41	.48977	.176732	.64534
42	.50039	.186127	.66351
43	.51105	.195902	.68202
44	.52178	.206078	.70088
45	.53256	.216674	.72012

γ = 1.3			
φ	X	Y	T
13°	.42223	.060781	.30459
12	.34604	.043839	.26731
11	.29172	.032765	.23591
10	.24823	.024693	.20790
9	.21141	.018522	.18220
8	.17917	.013699	.15822
7	.15032	.009896	.13558
6	.12408	.006903	.11405
5	.09993	.004574	.09342
4	.07748	.002805	.07357
3	.05645	.001517	.05438
2	.03664	.000650	.03577
+1	.01787	.000157	.01766
	+	+	+

γ = 1.3			
φ	X	Y	T
0°	.00000	.000000	.00000
	—	+	—
1	.01707	.000148	.01726
2	.03345	.000576	.03417
3	.04919	.001262	.05077
4	.06438	.002191	.06708
5	.07907	.003346	.08314
6	.09331	.004716	.09898
7	.10713	.006291	.11461
8	.12059	.008061	.13007
9	.13370	.010021	.14536
10	.14651	.012164	.16052
11	.15903	.014484	.17556
12	.17129	.016979	.19048
13	.18332	.019645	.20532
14	.19513	.022480	.22009
15	.20674	.025483	.23479
16	.21817	.028652	.24945
17	.22943	.031988	.26407
18	.24054	.035490	.27867
19	.25151	.039160	.29326
20	.26235	.042999	.30785
21	.27308	.047009	.32246
22	.28370	.051193	.33710
23	.29423	.055553	.35177
24	.30467	.060092	.36648
25	.31503	.064816	.38126
26	.32533	.069727	.39612
27	.33556	.074832	.41105
28	.34575	.080135	.42608
29	.35589	.085643	.44122
30	.36600	.091361	.45648
31	.37608	.097298	.47188
32	.38614	.103460	.48741
33	.39618	.109856	.50311
34	.40621	.116496	.51898
35	.41623	.123388	.53503
36	.42627	.130543	.55128
37	.43630	.137973	.56775
38	.44636	.145689	.58445
39	.45644	.153704	.60140
40	.46654	.162032	.61860
41	.47667	.170687	.63609
42	.48684	.179686	.65388
43	.49705	.189046	.67199
44	.50732	.198785	.69045
45	.51763	.208921	.70926

$\gamma = 1.4$

φ	X	Y	T
12°	.38169	.050213	.27842
11	.31095	.035777	.24262
10	.25994	.026303	.21230
9	.21890	.019424	.18517
8	.18405	.014209	.16024
7	.15350	.010180	.13695
6	.12610	.007054	.11495
5	.10116	.004650	.09399
4	.07818	.002839	.07390
3	.05681	.001530	.05455
2	.03678	.000654	.03584
+1	.01790	.000158	.01768
	+	+	+
0	.00000	.000000	.00000
	−	+	−
−1	.01705	.000148	.01725
2	.03334	.000573	.03412
3	.04897	.001255	.05065
4	.06401	.002174	.06689
5	.07853	.003316	.08285
6	.09257	.004667	.09857
7	.10618	.006217	.11409
8	.11940	.007958	.12941
9	.13227	.009881	.14457
10	.14482	.011981	.15957
11	.15708	.014252	.17445
12	.16907	.016692	.18921
13	.18082	.019296	.20388
14	.19234	.022062	.21846
15	.20366	.024989	.23298
16	.21479	.028075	.24745
17	.22575	.031321	.26187
18	.23655	.034726	.27627
19	.24721	.038292	.29065
20	.25774	.042019	.30503
21	.26814	.045909	.31941
22	.27844	.049965	.33382
23	.28864	.054190	.34826
24	.29874	.058585	.36275
25	.30877	.063156	.37729
26	.31873	.067907	.39190
27	.32863	.072841	.40658
28	.33847	.077965	.42136
29	.34827	.083283	.43624
30	.35802	.088803	.45123
31	.36775	.094530	.46635
32	.37744	.100472	.48161
33	.38712	.106637	.49701
34°	.39678	.113034	.51259
35	.40644	.119671	.52834
36	.41610	.126558	.54429
37	.42576	.133707	.56044
38	.43543	.141129	.57682
39	.44511	.148835	.59344
40	.45482	.156838	.61031
41	.46456	.165154	.62745
42	.47433	.173796	.64489
43	.48413	.182782	.66263
44	.49398	.192127	.68070
45	.50387	.201853	.69913

$\gamma = 1.5$

φ	X	Y	T
11°	.33734	.040046	.25112
10	.27427	.028320	.21743
9	.22753	.020482	.18848
8	.18946	.014783	.16243
7	.15692	.010491	.13839
6	.12824	.007218	.11588
5	.10245	.004731	.09457
4	.07891	.002875	.07423
3	.05717	.001543	.05472
2	.03693	.000657	.03591
+1	.01793	.000158	.01769
	+	+	+
0	.00000	.000000	.00000
	−	+	−
−1	.01702	.000147	.01723
2	.03324	.000571	.03406
3	.04875	.001248	.05054
4	.06365	.002158	.06669
5	.07799	.003286	.08256
6	.09184	.004619	.09818
7	.10525	.006146	.11358
8	.11825	.007857	.12877
9	.13089	.009746	.14379
10	.14320	.011805	.15865
11	.15521	.014030	.17338
12	.16694	.016417	.18798
13	.17842	.018962	.20248
14	.18968	.021664	.21689
15	.20072	.024520	.23123

γ = 1.5

φ	X	Y	T
16°	.21157	.027529	.24551
17	.22225	.030690	.25975
18	.23276	.034005	.27396
19	.24312	.037474	.28814
20	.25336	.041097	.30232
21	.26346	.044876	.31650
22	.27346	.048813	.33069
23	.28336	.052912	.34492
24	.29316	.057175	.35918
25	.30288	.061605	.37350
26	.31253	.066207	.38787
27	.32211	.070985	.40232
28	.33164	.075944	.41686
29	.34111	.081089	.43149
30	.35054	.086426	.44624
31	.35994	.091961	.46110
32	.36931	.097702	.47610
33	.37865	.103655	.49124
34	.38798	.109830	.50654
35	.39730	.116235	.52201
36	.40662	.122878	.53768
37	.41593	.129772	.55354
38	.42525	.136925	.56962
39	.43459	.144350	.58593
40	.44394	.152059	.60248
41	.45331	.160066	.61931
42	.46271	.168385	.63641
43	.47215	.177032	.65382
44	.48162	.186022	.67154
45	.49114	.195375	.68961

γ = 1.6

φ	X	Y	T
10°	.29272	.030982	.22363
9	.23770	.021749	.19224
8	.19554	.015433	.16483
7	.16064	.010830	.13994
6	.13051	.007392	.11686
5	.10380	.004815	.09517
4	.07966	.002912	.07458
3	.05755	.001557	.05490
2	.03708	.000661	.03598
+1	.01797	.000158	.01771
	+	+	+

γ = 1.6

φ	X	Y	T
0°	.00000	.000000	.00000
	—	+	—
−1	.01699	.000147	.01722
2	.03313	.000569	.03401
3	.04854	.001240	.05042
4	.06330	.002142	.06650
5	.07748	.003257	.08228
6	.09114	.004572	.09780
7	.10435	.006076	.11308
8	.11714	.007760	.12815
9	.12956	.009615	.14304
10	.14164	.011636	.15776
11	.15341	.013817	.17234
12	.16490	.016154	.18679
13	.17613	.018644	.20113
14	.18713	.021285	.21538
15	.19791	.024073	.22955
16	.20850	.027010	.24366
17	.21891	.030093	.25772
18	.22915	.033323	.27174
19	.23925	.036700	.28573
20	.24921	.040226	.29972
21	.25904	.043902	.31370
22	.26876	.047730	.32770
23	.27837	.051712	.34172
24	.28789	.055851	.35578
25	.29733	.060151	.36988
26	.30669	.064616	.38404
27	.31598	.069249	.39827
28	.32522	.074055	.41258
29	.33440	.079040	.42699
30	.34353	.084209	.44150
31	.35263	.089568	.45612
32	.36169	.095123	.47088
33	.37073	.100883	.48577
34	.37976	.106854	.50082
35	.38876	.113046	.51603
36	.39777	.119466	.53142
37	.40676	.126125	.54702
38	.41577	.133033	.56282
39	.42478	.140201	.57884
40	.43380	.147642	.59511
41	.44285	.155368	.61163
42	.45192	.163392	.62843
43	.46102	.171730	.64552
44	.47015	.180397	.66293
45	.47932	.189410	.68067

$\gamma = 1.7$

φ	X	Y	T
10°	.31860	.034841	.23157
9	.25006	.023321	.19658
8	.20245	.016185	.16746
7	.16472	.011206	.14158
6	.13294	.007578	.11788
5	.10521	.004903	.09579
4	.08043	.002949	.07493
3	.05793	.001570	.05507
2	.03723	.000664	.03605
+1	.01800	.000159	.01772
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01696	.000147	.01721
2	.03303	.000566	.03396
3	.04833	.001233	.05031
4	.06295	.002126	.06632
5	.07697	.003229	.08201
6	.09046	.004527	.09742
7	.10347	.006009	.11259
8	.11606	.007666	.12754
9	.12827	.009490	.14230
10	.14012	.011474	.15689
11	.15167	.013613	.17132
12	.16292	.015903	.18563
13	.17392	.018340	.19982
14	.18468	.020923	.21391
15	.19521	.023648	.22792
16	.20556	.026516	.24186
17	.21571	.029525	.25575
18	.22571	.032675	.26960
19	.23555	.035968	.28342
20	.24525	.039403	.29722
21	.25482	.042982	.31102
22	.26428	.046707	.32483
23	.27363	.050581	.33866
24	.28289	.054605	.35252
25	.29206	.058784	.36642
26	.30115	.063121	.38038
27	.31018	.067620	.39440
28	.31914	.072285	.40850
29	.32805	.077122	.42269
30	.33691	.082135	.43697
31	.34573	.087330	.45137
32	.35451	.092715	.46590
33	.36327	.098295	.48056
34	.37201	.104079	.49537
35	.38073	.110074	.51034
36	.38944	.116289	.52549

$\gamma = 1.7$

φ	X	Y	T
37°	.39815	.122733	.54082
38	.40686	.129416	.55636
39	.41558	.136349	.57212
40	.42430	.143543	.58812
41	.43305	.151011	.60436
42	.44181	.158766	.62088
43	.45061	.166821	.63768
44	.45943	.175192	.65478
45	.46828	.183895	.67222

$\gamma = 1.8$

φ	X	Y	T
9°	.26580	.025369	.20180
8	.21048	.017071	.17042
7	.16925	.011628	.14338
6	.13556	.007781	.11897
5	.10670	.004997	.09643
4	.08125	.002989	.07529
3	.05833	.001585	.05525
2	.03739	.000668	.03612
+1	.01803	.000159	.01774
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01693	.000146	.01719
2	.03293	.000564	.03391
3	.04812	.001226	.05020
4	.06260	.002111	.06613
5	.07647	.003201	.08174
6	.08979	.004483	.09705
7	.10262	.005944	.11211
8	.11501	.007575	.12695
9	.12701	.009368	.14158
10	.13866	.011317	.15604
11	.14999	.013416	.17034
12	.16102	.015661	.18450
13	.17180	.018049	.19855
14	.18233	.020577	.21249
15	.19263	.023242	.22634
16	.20274	.026045	.24013
17	.21267	.028985	.25385
18	.22242	.032060	.26753
19	.23202	.035272	.28118
20	.24148	.038622	.29482
21	.25082	.042111	.30844

$\gamma = 1.8$

φ	X	Y	T
22°	.26003	.045740	.32207
23	.26914	.049512	.33572
24	.27815	.053430	.34939
25	.28707	.057496	.36310
26	.29592	.061714	.37687
27	.30469	.066088	.39069
28	.31340	.070622	.40459
29	.32205	.075320	.41858
30	.33066	.080189	.43266
31	.33922	.085234	.44685
32	.34775	.090460	.46116
33	.35625	.095875	.47560
34	.36473	.101485	.49018
35	.37319	.107298	.50493
36	.38163	.113323	.51984
37	.39007	.119569	.53494
38	.39851	.126044	.55024
39	.40695	.132760	.56575
40	.41541	.139727	.58149
41	.42387	.146957	.59747
42	.43236	.154464	.61372
43	.44087	.162259	.63024
44	.44940	.170359	.64707
45	.45797	.178778	.66421

$\gamma = 1.9$

φ	X	Y	T
9°	.28737	.028267	.20836
8	.21997	.018142	.17377
7	.17426	.012104	.14531
6	.13836	.008003	.12012
5	.10826	.005098	.09710
4	.08207	.003032	.07566
3	.05872	.001600	.05544
2	.03753	.000672	.03619
+1	.01807	.000160	.01776
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01691	.000146	.01718
2	.03283	.000562	.03385
3	.04791	.001219	.05009
4	.06227	.002096	.06595
5	.07598	.003174	.08147
6	.08913	.004440	.09669

$\gamma = 1.9$

φ	X	Y	T
7°	.10179	.005881	.11165
8	.11399	.007487	.12637
9	.12580	.009251	.14088
10	.13725	.011166	.15521
11	.14837	.013227	.16938
12	.15919	.015429	.18341
13	.16975	.017770	.19732
14	.18007	.020245	.21111
15	.19016	.022855	.22482
16	.20005	.025596	.23845
17	.20975	0.28470	.25202
18	.21928	.031475	.26555
19	.22865	.034612	.27904
20	.23789	.037881	.29251
21	.24699	.041285	.30596
22	.25598	.044825	.31942
23	.26486	.048502	.33290
24	.27364	.052319	.34640
25	.28233	.056280	.35992
26	.29094	.060387	.37351
27	.29948	.064644	.38716
28	.30795	.069055	.40087
29	.31637	.073626	.41466
30	.32474	.078361	.42854
31	.33307	.083264	.44253
32	.34135	.088343	.45664
33	.34961	.093604	.47087
34	.35784	.099053	.48525
35	.36606	.0104699	.49978
36	.37426	.110548	.51447
37	.38245	.116609	.52935
38	.39064	.122892	.54442
39	.39883	.129407	.55969
40	.40703	.136164	.57519
41	.41524	.143175	.59093
42	.42346	.150452	.60693
43	.43170	.158008	.62320
44	.43997	.165857	.63976
45	.44827	.174013	.65664

$\gamma = 2.0$

φ	X	Y	T
8°	.23162	.019478	.17769
7	.17994	.012646	.14744

γ = 2.0

φ	X	Y	T
6°	.14140	.008242	.12135
5	.10992	.005203	.09781
4	.08294	.003074	.07605
3	.05914	.001615	.05563
2	.03770	.000675	.03627
+1	.01811	.000160	.01778
	+	+	+
0	.00000	.000000	.00000
	−	+	−
−1	.01688	.000146	.01716
2	.03273	.000559	.03380
3	.04771	.001212	.04999
4	.06193	.002081	.06577
5	.07550	.003148	.08121
6	.08849	.004398	.09632
7	.10097	.005819	.11118
8	.11300	.007402	.12579
9	.12461	.009138	.14019
10	.13587	.011021	.15440
11	.14679	.013045	.16844
12	.15742	.015207	.18234
13	.16777	.017502	.19611
14	.17788	.019928	.20977
15	.18776	.022484	.22333
16	.19744	.025168	.23682
17	.20693	.027979	.25024
18	.21625	.030917	.26362
19	.22542	.033983	.27695
20	.23444	.037177	.29026
21	.24333	.040501	.30356
22	.25210	.043955	.31686
23	.26076	.047543	.33017
24	.26932	.051266	.34350
25	.27780	.055128	.35687
26	.28619	.059131	.37028
27	.29451	.063279	.38374
28	.30276	.067577	.39728
29	.31096	.072027	.41089
30	.31911	.076636	.42459
31	.32721	.081409	.43839
32	.33527	.086351	.45230
33	.34331	.091468	.46634
34	.35131	.096767	.48052
35	.35930	.102256	.49484
36	.36727	.107941	.50933
37	.37523	.113832	.52400
38	.38319	.119937	.53885
39	.39114	.126265	.55390
40°	.39910	.132828	.56918
41	.40707	.139635	.58469
42	.41506	.146700	.60045
43	.42306	.154033	.61649
44	.43109	.161650	.63280
45	.43914	.169564	.64942

γ = 2.1

φ	X	Y	T
8°	.24666	.021250	.18243
7	.18644	.013279	.14981
6	.14471	.008508	.12267
5	.11167	.005316	.09855
4	.08383	.003120	.07645
3	.05955	.001630	.05582
2	.03785	.000679	.03635
+1	.01814	.000161	.01779
	+	+	+
0	.00000	.000000	.00000
	−	+	−
−1	.01685	.000145	.01715
2	.03263	.000557	.03375
3	.04751	.001205	.04988
4	.06161	.002067	.06560
5	.07503	.003122	.08095
6	.08787	.004357	.09599
7	.10018	.005760	.11074
8	.11203	.007319	.12525
9	.12347	.009028	.13953
10	.13454	.010880	.15363
11	.14528	.012870	.16755
12	.15571	.014992	.18132
13	.16587	.017244	.19496
14	.17579	.019624	.20849
15	.18547	.022129	.22192
16	.19496	.024758	.23527
17	.20425	.027510	.24855
18	.21337	.030385	.26178
19	.22233	.033384	.27497
20	.23115	.036507	.28813
21	.23984	.039755	.30127
22	.24841	.043129	.31442
23	.25687	.046633	.32757
24	.26523	.050268	.34074

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25	[illegible]	.050176	.34322
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7	.09649	.005484	.10862
8	[illegible]	.006940	.12264
9	.11819	.008529	.13642
10	.12844	.010243	.14998
11	.13834	.012078	.16335
12	.14793	.014029	.17655
13	.15724	.016093	.18961
14	.16630	.018268	.20254
15	.17514	.020552	.21536

$\gamma = 2.3$			
φ	X	Y	T
0°	.00000	.000000	.00000
	—	+	—
−1	.01680	.000145	.01712
2	.03244	.000553	.03365
3	.04712	.001192	.04967
4	.06097	.002038	.06525
5	.07412	.003072	.08045
6	.08666	.004278	.09530
7	.09865	.005645	.10987
8	.11018	.007161	.12417
9	.12127	.008819	.13824
10	.13200	.010613	.15211
11	.14238	.012537	.16580
12	.15245	.014586	.17934
13	.16225	.016758	.19273
14	.17180	.019050	.20601
15	.18112	.021460	.21918
16	.19023	.023987	.23227
17	.19916	.026631	.24529
18	.20791	.029389	.25824
19	.21650	.032264	.27116
20	.22495	.035256	.28404
21	.23326	.038365	.29690
22	.24146	.041593	30975
23	.24955	.044943	.32261
24	.25753	.048415	.33549
25	.26543	.052013	.34839
26	.27324	.055740	.36133
27	.28098	.059599	.37431
28	.28866	.063593	.38736
29	.29627	.067726	.40048
30	.30383	.072004	.41367
31	.31134	.076430	.42697
32	.31881	.081010	.44036
33	.32625	.085749	.45387
34	.33366	.090654	.46751
35	.34105	.095731	.48128
36	.34842	.100988	.49521
37	.35577	.106430	.50931
38	.36312	.112067	.52358
39	.37046	.117908	.53805
40	.37781	.123961	.55272
41	.38516	.130237	.56761
42	.39251	.136747	.58274
43	.39988	.143501	.59813
44	.40727	.150513	.61378
45	.41468	.157795	.62973

$\gamma = 2.4$			
φ	X	Y	T
7°	.21464	.016130	.15914
6	.15685	.009501	.12726
5	.11760	.005706	.10098
4	.08675	.003269	.07772
3	.06087	.001680	.05643
2	.03834	.000692	.03658
+1	.01824	.000162	.01785
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01677	.000145	.01711
2	.03235	.000551	.03360
3	.04693	.001186	.04957
4	.06066	.002025	.06508
5	.07368	.003048	.08020
6	.08607	.004241	.09498
7	.09792	.005590	.10945
8	.10928	.007085	.12365
9	.12022	.008719	.13762
10	.13078	.010485	.15139
11	.14099	.012378	.16497
12	.15090	.014394	.17839
13	.16053	.016528	.19167
14	.16991	.018779	.20482
15	.17906	.021145	.21787
16	.18800	.023625	.23084
17	.19675	.026217	.24373
18	.20533	.028922	.25656
19	.21375	.031740	.26934
20	.22203	.034670	.28209
21	.23018	.037716	.29482
22	.23820	.040876	.30754
23	.24612	.044155	.32027
24	.25393	.047553	.33300
25	.26165	.051073	.34546
26	.26930	.054718	.35856
27	.27686	.058491	.37140
28	.28436	.062395	.38430
29	.29180	.066435	.39726
30	.29919	.070615	.41031
31	.30653	.074939	.42345
32	.31383	.079412	.43669
33	.32109	.084041	.45004
34	.32833	.088830	.46352
35	.33554	.093786	.47713
36	.34273	.098916	.49089
37	.34991	.104227	.50481
38	.35708	.109727	.51891
39	.36424	.115425	.53320

$\gamma = 2.4$

φ	X	Y	T
40°	.37140	.121330	.54769
41	.37857	.127451	.56240
42	.38575	.133799	.57734
43	.39293	.140384	.59253
44	.40013	.147220	.60799
45	.40736	.154318	.62373

$\gamma = 2.5$

φ	X	Y	T
7°	.23004	.017756	.16361
6	.16193	.009927	.12907
5	.11987	.005856	.10188
4	.08781	.003322	.07816
3	.06134	.001696	.05663
2	.03851	.000695	.03665
+1	.01828	.000162	.01786
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01675	.000144	.01710
2	.03225	.000548	.03355
3	.04673	.001179	.04946
4	.06035	.002011	.06491
5	.07324	.003025	.07996
6	.08549	.004204	.09465
7	.09719	.005536	.10903
8	.10841	.007012	.12314
9	.11919	.008623	.13701
10	.12959	.010362	.15067
11	.13964	.012226	.16415
12	.14939	.014208	.17746
13	.15886	.016307	.19062
14	.16808	.018519	.20367
15	.17706	.020843	.21660
16	.18584	.023277	.22945
17	.19443	.025821	.24222
18	.20285	.028475	.25493
19	.21110	.031238	.26759
20	.21922	.034111	.28021
21	.22720	.037095	.29281
22	.23506	.040192	.30540
23	.24281	.043403	.31799
24	.25047	.046730	.33060
25	.25803	.050176	.34322
26	.26550	.053743	.35588
27	.27291	.057435	.36858
28°	.28025	.061254	.38134
29	.28752	.065206	.39417
30	.29475	.069293	.40707
31	.30192	.073520	.42006
32	.30906	.077893	.43315
33	.31616	.082416	.44635
34	.32323	.087096	.45967
35	.33028	.091939	.47312
36	.33730	.096950	.48672
37	.34431	.102138	.50049
38	.35131	.107509	.51442
39	.35830	.113073	.52854
40	.36530	.118838	.54286
41	.37229	.124813	.55739
42	.37930	.131008	.57215
43	.38631	.137435	.58715
44	.39334	.144105	.60242
45	.40038	.151030	.61797

$\gamma = 2.6$

φ	X	Y	T
6°	.16780	.010425	.13110
5	.12232	.006019	.10283
4	.08892	.003379	.07863
3	.06182	.001714	.05685
2	.03869	.000699	.03674
+1	.01832	.000163	.01788
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01672	.000144	.01708
2	.03216	.000547	.03350
3	.04655	.001173	.04936
4	.06005	.001999	.06475
5	.07282	.003002	.07972
6	.08493	.004168	.09433
7	.09649	.005484	.10862
8	.10756	.006940	.12264
9	.11819	.008529	.13642
10	.12844	.010243	.14998
11	.13834	.012078	.16335
12	.14793	.014029	.17655
13	.15724	.016093	.18961
14	.16630	.018268	.20254
15	.17514	.020552	.21536

γ = 2.6			
φ	X	Y	T
16°	.18376	.022943	.22810
17	.19219	.025441	.24075
18	.20045	.028045	.25334
19	.20855	.030756	.26588
20	.21651	.033574	.27838
21	.22434	.036501	.29086
22	.23205	.039537	.30333
23	.23965	.042684	.31579
24	.24714	.045944	.32827
25	.25455	.049319	.34076
26	.26188	.052813	.35329
27	.26913	.056428	.36586
28	.27631	.060167	.37848
29	.28343	.064035	.39117
30	.29050	.068034	.40393
31	.29752	.072171	.41678
32	.30450	.076449	.42973
33	.31145	.080873	.44278
34	.31836	.085450	.45595
35	.32525	.090184	.46926
36	.33212	.095084	.48271
37	.33897	.100155	.49631
38	.34582	.105405	.51009
39	.35265	.110842	.52405
40	.35948	.116475	.53820
41	.36632	.122312	.55256
42	.37316	.128365	.56715
43	.38001	.134642	.58198
44	.38687	.141156	.59707
45	.39376	.147919	.61244

γ = 2.7			
φ	X	Y	T
6°	.17470	.011021	.13339
5	.12496	.006198	.10386
4	.09007	.003439	.07912
3	.06230	.001732	.05707
2	.03885	.000704	.03682
+1	.01835	.000163	.01790
	+	+	+
0	.00000	.000000	.00000
	−	+	−
−1	.01669	.000144	.01707
2	.03207	.000544	.03345
3	.04636	.001167	.04927

γ = 2.7			
φ	X	Y	T
4°	.05976	.001985	.06459
5	.07240	.002979	.07948
6	.08439	.004132	.09401
7	.09581	.005432	.10822
8	.10673	.006870	.12215
9	.11722	.008437	.13583
10	.12732	.010127	.14929
11	.13708	.011934	.16256
12	.14652	.013855	.17567
13	.15569	.015886	.18862
14	.16460	.018025	.20144
15	.17328	.020270	.21416
16	.18175	.022620	.22678
17	.19004	.025074	.23932
18	·19815	.027631	.25180
19	.20610	.030293	.26422
20	.21392	.033059	.27661
21	.22160	.035930	.28897
22	.22916	.038907	.30131
23	.23661	.041993	.31366
24	.24396	.045190	.32601
25	.25122	.048498	.33838
26	.25840	.051922	.35078
27	.26550	.055464	.36323
28	.27254	.059127	.37572
29	.27952	.062915	.38828
30	.28644	.066832	.40091
31	.29331	.070883	.41362
32	.30015	.075070	.42643
33	.30695	.079401	.43935
34	.31371	.083880	.45238
35	.32045	.088513	.46554
36	.32717	.093307	.47884
37	.33388	.098267	.49230
38	.34057	.103402	.50592
39	.34725	.108720	.51972
40	.35394	.114228	.53372
41	.36062	.119935	.54792
42	.36731	.125852	.56235
43	.37401	.131989	.57701
44	.38071	.138356	.59193
45	.38744	.144965	.60712

γ = 2.8			
φ	X	Y	T
6°	.18312	.011761	.13603
5	.12786	.006395	.10493
4	.09130	.003502	.07961
3	.06282	.001751	.05728
2	.03903	.000708	.03689
+1	.01839	.000163	.01791
	+	+	+
0	.00000	.000000	.00000
	—	+	—
—1	.01667	.000143	.01706
2	.03197	.000542	.03341
3	.04618	.001161	.04917
4	.05947	.001973	.06442
5	.07199	.002957	.07925
6	.08385	.004098	.09370
7	.09513	.005383	.10783
8	.10592	.006802	.12167
9	.11627	.008348	.13526
10	.12623	.010014	.14863
11	.13584	.011795	.16180
12	.14514	.013687	.17480
13	.15416	.015687	.18765
14	.16293	.017791	.20037
15	.17147	.019999	.21298
16	.17980	.022309	.22550
17	.18794	.024721	.23793
18	.19591	.027234	.25030
19	.20373	.029848	.26261
20	.21140	.032563	.27489
21	.21894	.035382	.28713
22	.22636	.038304	.29936
23	.23367	.041332	.31159
24	.24088	.044468	.32382
25	.24800	.047713	.33608
26	.25504	.051070	.34836
27	.26201	.054543	.36068
28	.26891	.058133	.37305
29	.27574	.061846	.38548
30	.28253	.065684	.39798
31	.28926	.069652	.41057
32	.29596	.073755	.42325
33	.30262	.077996	.43603
34	.30924	.082383	.44892
35	.31584	.086919	.46195
36	.32242	.091612	.47511
37	.32898	.096469	.48842
38	.33553	.101495	.50190
39	.34208	.106699	.51555

γ = 2.8			
φ	X	Y	T
40°	.34861	.112089	.52940
41	.35515	.117674	.54345
42	.36170	.123463	.55772
43	.36825	.129466	.57222
44	.37481	.135694	.58698
45	.38139	.142158	.60200

γ = 2.9			
φ	X	Y	T
6°	.19388	.012730	.13921
5	.13105	.006616	.10611
4	.09258	.003570	.08015
3	.06334	.001772	.05753
2	.03921	.000712	.03699
+1	.01842	.000164	.01793
0	.00000	.000000	.00000
−1	.01664	.000143	.01704
2	.03188	.000540	.03335
3	.04600	.001155	.04906
4	.05918	.001960	.06426
5	.07158	.002935	.07902
6	.08332	.004064	.09339
7	.09448	.005335	.10744
8	.10513	.006737	.12119
9	.11534	.008263	.13469
10	.12517	.009906	.14797
11	.13464	.011661	.16104
12	.14380	.013525	.17395
13	.15269	.015494	.18670
14	.16132	.017566	.19933
15	.16972	.019738	.21183
16	.17791	.022010	.22424
17	.18592	.024381	.23657
18	.19375	.026851	.24883
19	.20143	.029420	.26104
20	.20897	.032088	.27320
21	.21637	.034856	.28534
22	.22366	.037726	.29746
23	.23083	.040698	.30958
24	.23791	.043776	.32170
25	.24490	.046960	.33383
26	.25181	.050254	.34600
27	.25864	.053660	.35820

γ = 2.9

φ	X	Y	T
28°	.26541	.057182	.37045
29	.27211	.060822	.38276
30	.27876	.064585	.39514
31	.28537	.068475	.40761
32	.29193	.072496	.42016
33	.29845	.076653	.43281
34	.30495	.080951	.44558
35	.31141	.085396	.45847
36	.31786	.089994	.47150
37	.32429	.094751	.48467
38	.33070	.099674	.49801
39	.33711	.104771	.51153
40	.34351	.110049	.52523
41	.34992	.115517	.53913
42	.35632	.121185	.55325
43	.36274	.127062	.56759
44	.36916	.133158	.58219
45	.37560	.139485	.59705

γ = 3.0

φ	X	Y	T
5°	.13457	.006862	.10736
4	.09393	.003641	.08068
3	.06387	.001791	.05775
2	.03939	.000717	.03707
+1	.01846	.000164	.01795
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01662	.000142	.01703
2	.03179	.000538	.03331
3	.04582	.001149	.04897
4	.05890	.001948	.06411
5	.07119	.002914	.07880
6	.08280	.004031	.09310
7	.09383	.005287	.10706
8	.10436	.006672	.12074
9	.11444	.008178	.13415
10	.12413	.009799	.14733
11	.13347	.011530	.16032
12	.14250	.013367	.17313
13	.15125	.015307	.18579
14	.15975	.017346	.19831
15	.16802	.019485	.21072

γ = 3.0

φ	X	Y	T
16°	.17608	.021720	.22303
17	.18396	.024053	.23526
18	.19166	.026481	.24742
19	.19921	.029007	.25952
20	.20661	.031629	.27158
21	.21389	.034349	.28361
22	.22104	.037168	.29563
23	.22810	.040088	.30763
24	.23505	.043110	.31965
25	.24191	.046236	.33167
26	.24869	.049470	.34372
27	.25539	.052813	.35581
28	.26203	.056269	.36794
29	.26861	.059841	.38014
30	.27513	.063533	.39240
31	.28161	.067348	.40474
32	.28805	.071292	.41717
33	.29444	.075368	.42970
34	.30081	.079583	.44234
35	.30715	.083941	.45510
36	.31347	.088448	.46800
37	.31977	.093110	.48105
38	.32606	.097936	.49426
39	.33234	.102930	.50763
40	.33861	.108102	.52119
41	.34489	.113460	.53495
42	.35116	.119012	.54893
43	.35745	.124769	.56313
44	.36374	.130741	.57758
45	.37004	.136938	.59229

γ = 3.1

φ	X	Y	T
5°	.13855	.007143	.10875
4	.09536	.003716	.08126
3	.06442	.001812	.05799
2	.03958	.000721	.03715
+1	.01850	.000165	.01797
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01659	.000142	.01701
2	.03171	.000536	.03326
3	.04564	.001143	.04887

γ = 3.4

φ	X	Y	T
16°	.16928	.020655	.21845
17	.17668	.022847	.23030
18	.18391	.025127	.24208
19	.19099	.027496	.25380
20	.19793	.029953	.26548
21	.20474	.032499	.27712
22	.21144	.035136	.28873
23	.21803	.037866	.30035
24	.22452	.040689	.31196
25	.23093	.043608	.32357
26	.23725	.046625	.33522
27	.24351	.049742	.34689
28	.24969	.052963	.35860
29	.25582	.056290	.37037
30	.26190	.059727	.38220
31	.26792	.063277	.39411
32	.27391	.066945	.40609
33	.27986	.070735	.41818
34	.28577	.074652	.43036
35	.29166	.078700	.44267
36	.29753	.082885	.45510
37	.30338	.087213	.46766
38	.30921	.091690	.48038
39	.31503	.096322	.49327
40	.32085	.101117	.50632
41	.32667	.106083	.51957
42	.33248	.111228	.53302
43	.33830	.116560	.54669
44	.34412	.122089	.56060
45	.34996	.127826	.57475

γ = 3.5

φ	X	Y	T
4°	.10210	.004086	.08383
3	.06683	.001905	.05901
2	.04036	.000740	.03750
+1	.01865	.000166	.01804
	+	+	+
0	.00000	.000000	.00000
	−	+	−
−1	.01649	.000141	.01696
2	.03135	.000529	.03307
3	.04496	.001121	.04850
4	.05755	.001890	.06335
5	.06930	.002813	.07771
6	.08035	.003876	.09166

γ = 3.5

φ	X	Y	T
7°	.09080	.005066	.10
8	.10074	.006374	.11
9	.11022	.007791	.13
10	.11931	.009311	.14
11	.12806	.010931	.15
12	.13649	.012646	.16
13	.14464	.014453	.18
14	.15255	.016351	.19
15	.16023	.018337	.20
16	.16770	.020410	.21
17	.17500	.022570	.22
18	.18212	.024816	.24
19	.18910	.027149	.25
20	.19593	.029569	.26
21	.20264	.032076	.27
22	.20923	.034672	.28
23	.21571	.037359	.29
24	.22210	.040137	.31
25	.22841	.043009	.32
26	.23463	.045978	.33
27	.24078	.049045	.34
28	.24687	.052213	.35
29	.25289	.055485	.36
30	.25887	.058865	.37
31	.26479	.062356	.39
32	.27068	.065962	.40
33	.27652	.069688	.41
34	.28234	.073538	.42
35	.28813	.077517	.43
36	.29389	.081631	.45
37	.29964	.085884	.46
38	.30537	.090283	.47
39	.31110	.094835	.48
40	.31681	.099546	.50
41	.32252	.104425	.51
42	.32823	.109478	.52
43	.33395	.114716	.54
44	.33967	.120147	.55
45	.34540	.125781	.57

γ = 3.6

φ	X	Y	T
4°	.10410	.004190	.08
3	.06748	.001931	.05
2	.04056	.000745	.03
+1	.01868	.000167	.01
	+	+	

$\gamma = 3.2$

φ	X	Y	T
40°	.32939	104460	.51352
41	.33543	.109613	.52702
42	.34146	.114951	.54072
43	.34750	.120486	.55464
44	.35355	.126225	.56881
45	.35961	.132181	.58323

$\gamma = 3.3$

φ	X	Y	T
5°	.14836	.007850	.11199
4	.09850	.003885	.08249
3	.06559	.001857	.05849
2	.03996	.000730	.03733
+1	.01857	.000165	.01800
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01654	.000142	.01698
2	.03153	.000532	.03317
3	.04530	.001132	.04869
4	.05808	.001912	.06365
5	.07004	.002852	.07814
6	.08130	.003936	.09223
7	.09198	.005151	.10596
8	.10214	006488	.11940
9	.11185	.007940	.13256
10	.12117	.009499	.14549
11	.13014	.011161	.15822
12	.13880	.012922	.17076
13	.14718	.014779	.18315
14	.15531	.016731	19540
15	.16321	.018774	.20753
16	.17091	.020909	.21956
17	.17842	.023134	.23150
18	.18576	.025449	.24337
19	.19295	.027854	.25518
20	.20000	.030350	.26694
21	.20692	.032937	.27868
22	.21372	.035617	.29039
23	.22042	.038391	.30210
24	.22702	.041261	.31380
25	.23353	.044229	.32551
26	.23997	.047296	.33725
27	.24633	.050466	.34902
28°	.25262	.053742	.36083
29	.25885	.057126	.37270
30	.26503	.060623	.38464
31	.27117	.064236	.39665
32	.27726	.067968	.40874
33	.28331	.071825	.42093
34	.28933	.075810	.43322
35	.29533	.079930	.44564
36	.30130	.084190	.45818
37	.30725	.088596	.47086
38	.31320	.093154	.48369
39	.31913	.097871	.49669
40	.32505	.102754	.50987
41	.33097	.107811	.52324
42	.33689	.113051	.53681
43	.34282	.118482	.55061
44	.34875	.124114	.56464
45	.35470	.129957	.57892

$\gamma = 3.4$

φ	X	Y	T
5°	.15467	.008315	.11392
4	.10023	.003979	.08314
3	.06619	.001881	.05875
2	.04015	.000735	.03742
+1	01861	.000166	.01802
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01651	.000141	.01697
2	.03144	.000531	.03312
3	.04513	.001127	.04859
4	.05781	.001901	.06349
5	.06967	.002833	.07792
6	.08082	.003906	.09194
7	.09138	.005108	.10560
8	.10143	.006430	.11896
9	.11103	.007864	.13205
10	.12023	.009404	.14490
11	.12908	.011044	.15754
12	.13763	.012782	.17000
13	.14589	.014614	.18230
14	.15391	.016538	.19446
15	.16170	.018552	.20651

$\gamma = 3.4$

φ	X	Y	T
16°	.16928	.020655	.21845
17	.17668	.022847	.23030
18	.18391	.025127	.24208
19	.19099	.027496	.25380
20	.19793	.029953	.26548
21	.20474	.032499	.27712
22	.21144	.035136	.28873
23	.21803	.037866	.30035
24	.22452	.040689	.31196
25	.23093	.043608	.32357
26	.23725	.046625	.33522
27	.24351	.049742	.34689
28	.24969	.052963	.35860
29	.25582	.056290	.37037
30	.26190	.059727	.38220
31	.26792	.063277	.39411
32	.27391	.066945	.40609
33	.27986	.070735	.41818
34	.28577	.074652	.43036
35	.29166	.078700	.44267
36	.29753	.082885	.45510
37	.30338	.087213	.46766
38	.30921	.091690	.48038
39	.31503	.096322	.49327
40	.32085	.101117	.50632
41	.32667	.106083	.51957
42	.33248	.111228	.53302
43	.33830	.116560	.54669
44	.34412	.122089	.56060
45	.34996	.127826	.57475

$\gamma = 3.5$

φ	X	Y	T
4°	.10210	.004080	.08383
3	.06683	.001905	.05901
2	.04036	.000740	.03750
+1	.01865	.000166	.01804
	+	+	+
0	.00000	.000000	.00000
	—	+	—
—1	.01649	.000141	.01696
2	.03135	.000529	.03307
3	.04496	.001121	.04850
4	.05755	.001890	.06335
5	.06930	.002813	.07771
6	.08035	.003876	.09166

$\gamma = 3.5$

φ	X	Y	T
7°	.09080	.005066	.10525
8	.10074	.006374	.11854
9	.11022	.007791	.13155
10	.11931	.009311	.14432
11	.12806	.010931	.15688
12	.13649	.012646	.16926
13	.14464	.014453	.18148
14	.15255	.016351	.19356
15	.16023	.018337	.20552
16	.16770	.020410	.21737
17	.17500	.022570	.22914
18	.18212	.024816	.24083
19	.18910	.027149	.25246
20	.19593	.029569	.26405
21	.20264	.032076	.27560
22	.20923	.034672	.28713
23	.21571	.037359	.29864
24	.22210	.040137	.31016
25	.22841	.043009	.32169
26	.23463	.045978	.33323
27	.24078	.049045	.34481
28	.24687	.052213	.35643
29	.25289	.055485	.36810
30	.25887	.058865	.37983
31	.26479	.062356	.39164
32	.27068	.065962	.40352
33	.27652	.069688	.41550
34	.28234	.073538	.42759
35	.28813	.077517	.43978
36	.29389	.081631	.45811
37	.29964	.085884	.46456
38	.30537	.090283	.47717
39	.31110	.094835	.48994
40	.31681	.099546	.50289
41	.32252	.104425	.51602
42	.32823	.109478	.52935
43	.33395	.114716	.54290
44	.33967	.120147	.55668
45	.34540	.125781	.57070

$\gamma = 3.6$

φ	X	Y	T
4°	.10410	.004190	.08457
3	.06748	.001931	.05928
2	.04056	.000745	.03760
+1	.01868	.000167	.01806
	+	+	+

γ = 3.6				γ = 3.7			
φ	X	Y	T	φ	X	Y	T
0°	.00000	.000000	.00000	4°	.10627	.004311	.08536
				3	.06816	.001957	.05956
	—	+	—	2	.04076	.000750	.03769
—1	.01646	.000141	.01695	+1	.01872	.000167	.01808
2	.03127	.000527	.03303		+	+	+
3	.04479	.001116	.04840	0	.00000	.000000	.00000
					—	+	—
4	.05729	.001878	.06320	—1	.01644	.000140	.01694
5	.06894	.002794	.07750	2	.03119	.000525	.03299
6	.07989	.003847	.09139	3	.04463	.001110	.04832
7	.09023	.005025	.10491	4	.05704	.001868	.06306
8	.10005	.006318	.11812	5	.06859	.002776	.07730
9	.10943	.007719	.13105	6	.07943	.003819	.09112
10	.11841	.009221	.14375	7	.08967	.004984	.10458
11	.12705	.010821	.15623	8	.09939	.006264	.11771
12	.13537	.012514	.16853	9	.10866	.007648	.13058
13	.14342	.014298	.18067	10	.11754	.009133	.14320
14	.15122	.016169	.19267	11	.12607	.010713	.15560
15	.15879	.018128	.20454	12	.13429	.012385	.16782
16	.16616	.020172	.21631	13	.14223	.014146	.17988
17	.17335	.022301	.22800	14	.14993	.015993	.19180
18	.18037	.024515	.23960	15	.15740	.017925	.20360
19	.18724	.026813	.25115	16	.16467	.019941	.21529
20	.19397	.029197	.26265	17	.17176	.022040	.22689
21	.20058	.031667	.27411	18	.17868	.024223	.23841
22	.20707	.034224	.28555	19	.18545	.026488	.24988
23	.21346	.036869	.29698	20	.19209	.028837	.26129
24	.21975	.039604	.30840	21	.19859	.031271	.27267
25	.22595	.042432	.31984	22	.20499	.033790	.28402
26	.23208	.045353	.33130	23	.21128	.036396	.29537
27	.23813	.048371	.34278	24	.21748	.039090	.30671
28	.24412	.051488	.35431	25	.22359	.041874	.31805
29	.25005	.054708	.36588	26	.22962	.044751	.32942
30	.25592	.058033	.37752	27	.23558	.047722	.34082
31	.26175	.061467	.38923	28	.24147	.050791	.35225
32	.26754	.065014	.40101	29	.24731	.053960	.36374
33	.27329	.068679	.41289	30	.25309	.057232	.37528
34	.27901	.072465	.42488	31	.25883	.060612	.38690
35	.28471	.076378	.43697	32	.26453	.064103	.39859
36	.29038	.080422	.44919	33	.27019	.067708	.41037
37	.29603	.084604	.46155	34	.27581	.071433	.42226
38	.30166	.088928	.47405	35	.28141	.075282	.43426
39	.30729	.093403	.48671	36	.28699	.079261	.44638
40	.31291	.098034	.49954	37	.29255	.083374	.45863
41	.31852	.102829	.51256	38	.29809	.087627	.47103
42	.32413	.107796	.52578	39	.30363	.092027	.48358
43	.32975	.112944	.53921	40	.30915	.096582	.49631
44	.33537	.118281	.55287	41	.31467	.101297	.50921
45	.34101	.123817	.56677	42	.32019	.106181	.52232

$\gamma = 3.7$

φ	X	Y	T
43°	.32572	.111242	.53564
44	.33125	.116489	.54918
45	.33678	.121932	.56296

$\gamma = 3.8$

φ	X	Y	T
4°	.10864	.004444	.08619
3	.06886	.001984	.05985
2	.04097	.000755	.03778
+1	.01876	.000168	.01809
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01641	.000141	.01693
2	.03111	.000523	.03294
3	.04448	.001105	.04823
4	.05678	.001857	.06291
5	.06824	.002757	.07710
6	.07898	.003791	.09085
7	.08912	.004945	.10424
8	.09874	.006210	.11731
9	.10791	.007580	.13010
10	.11668	.009048	.14264
11	.12511	.010609	.15498
12	.13322	.012260	.16712
13	.14107	.013998	.17911
14	.14866	.015821	.19095
15	.15604	.017728	.20266
16	.16321	.019717	.21428
17	.17020	.021787	.22580
18	.17703	.023940	.23724
19	.18370	.026173	.24862
20	.19024	.028489	.25996
21	.19666	.030888	.27125
22	.20296	.033370	.28253
23	.20916	.035938	.29378
24	.21527	.038592	.30504
25	.22128	.041334	.31630
26	.22722	.044168	.32758
27	.23309	.047094	.33889
28	.23890	.050116	.35024
29	.24465	.053236	.36164
30	.25034	.056458	.37310
31	.25599	.059785	.38462
32	.26160	.063221	.39622
33	.26717	.066770	.40792
34°	.27271	.070436	.41971
35	.27822	.074224	.43161
36	.28371	.078139	.44363
37	.28917	.082186	.45578
38	.29463	.086371	.46808
39	.30007	.090701	.48053
40	.30551	.095181	.49316
41	.31094	.099820	.50596
42	.31637	.104624	.51896
43	.32180	.109602	.53217
44	.32723	.114763	.54560
45	.33268	.120116	.55927

$\gamma = 3.9$

φ	X	Y	T
4°	.11126	.004592	.08709
3	.06960	.002013	.06015
2	.04118	.000761	.03788
+1	.01880	.000168	.01811
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01639	.000140	.01691
2	.03102	.000521	.03289
3	.04431	.001099	.04814
4	.05654	.001846	.06277
5	.06790	.002739	.07690
6	.07854	.003763	.09059
7	.08858	.004906	.10392
8	.09810	.006159	.11691
9	.10717	.007513	.12963
10	.11584	.008964	.14211
11	.12417	.010507	.15437
12	.13219	.012138	.16644
13	.13993	.013855	.17835
14	.14743	.015655	.19011
15	.15471	.017537	.20176
16	.16179	.019499	.21329
17	.16869	.021542	.22473
18	.17542	.023665	.23610
19	.18200	.025868	.24740
20	.18845	.028152	.25866
21	.19478	.030517	.26987
22	.20099	.032964	.28107
23	.20710	.035494	.29224
24	.21312	.038110	.30342

γ = 3.9

φ	X	Y	T
25°	.21905	.040813	.31460
26	.22490	.043604	.32580
27	.23068	.046487	.33703
28	.23640	.049464	.34829
29	.24206	.052537	.35960
30	.24767	.055711	.37097
31	.25323	.058987	.38241
32	.25875	.062371	.39392
33	.26424	.065865	.40552
34	.26969	.069474	.41722
35	.27512	.073204	.42903
36	.28052	.077057	.44096
37	.28590	.081041	.45302
38	.29127	.085161	.46522
39	.29663	.089422	.47758
40	.30198	.093832	.49010
41	.30732	.098396	.50280
42	.31266	.103124	.51570
43	.31801	.108023	.52880
44	.32336	.113101	.54212
45	.32872	.118367	.55568

γ = 4.0

φ	X	Y	T
4°	.11417	.004759	.08807
3	.07036	.002044	.06046
2	.04140	.000766	.03797
+1	.01884	.000169	.01813
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01636	.000140	.01690
2	.03094	.000519	.03285
3	.04415	.001094	.04805
4	.05629	.001836	.06263
5	.06756	.002722	.07670
6	.07811	.003737	.09033
7	.08805	.004868	.10359
8	.09747	.006108	.11652
9	.10644	.007448	.12917
10	.11502	.008883	.14158
11	.12325	.010408	.15377
12	.13117	.012019	.16577
13	.13882	.013715	.17760
14	.14623	.015493	.18929
15	.15342	.017351	.20086
16°	.16040	.019288	.21232
17	.16721	.021304	.22369
18	.17385	.023399	.23498
19	.18035	.025572	.24621
20	.18671	.027824	.25739
21	.19295	.030156	.26853
22	.19907	.032569	.27964
23	.20510	.035065	.29074
24	.21103	.037643	.30183
25	.21688	.040307	.31293
26	.22264	.043059	.32405
27	.28834	.045900	.33520
28	.23398	.048833	.34638
29	.23955	.051862	.35761
30	.24508	.054988	.36889
31	.25056	.058216	.38024
32	.25600	.061549	.39167
33	.26140	.064991	.40318
34	.26677	.068546	.41479
35	.27212	.072219	.42651
36	.27744	.076014	.43835
37	.28274	.079937	.45032
38	.28802	.083993	.46242
39	.29330	.088189	.47469
40	.29856	.092530	.48711
41	.30382	.097024	.49971
42	.30908	.101678	.51251
43	.31435	.106500	.52551
44	.31961	.111498	.53872
45	.32489	.116682	.55218

γ = 4.1

φ	X	Y	T
4°	.11746	.004949	.08914
3	.07116	.002075	.06078
2	.04162	.000772	.03807
+1	.01888	.000169	.01815
	+	+	+
0	.00000	.000000	.00000
	—	+	—
−1	.01634	.000139	.01689
2	.03085	.000517	.03281
3	.04399	.001089	.04797
4	.05605	.001825	.06250
5	.06723	.002704	.07651
6	.07769	.003710	.09008

γ = 4.4

φ	X	Y	T
34°	.25593	.065125	.40567
35	.26098	.068592	.41705
36	.26600	.072173	.42855
37	.27100	.075874	.44017
38	.27599	.079700	.45193
39	.28096	.083656	.46384
40	.28593	.087749	.47590
41	.29089	.091985	.48814
42	.29584	.096371	.50056
43	.30080	.100914	.51317
44	.30576	.105623	.52600
45	.31073	.110505	.53906

γ = 4.5

φ	X	Y	T
3°	.07474	.002219	.06216
2	.04255	.000795	.03848
+1	.01904	.000171	.01823
	+	+	+
0	.00000	.000000	.00000
−1	.01624	.000138	.01683
2	.03054	.000510	.03263
3	.04338	.001069	.04762
4	.05512	.001785	.06196
5	.06596	.002638	.07576
6	.07606	.003609	.08910
7	.08555	.004690	.10205
8	.09452	.005870	.11467
9	.10303	.007142	.12700
10	.11116	.008502	.13907
11	.11895	.009945	.15093
12	.12644	.011468	.16259
13	.13366	.013067	.17409
14	.14063	.014742	.18544
15	.14740	.016491	.19666
16	.15397	.018313	.20778
17	.16036	.020207	.21879
18	.16660	.022173	.22973
19	.17269	.024212	.24061
20	.17865	.026323	.25143
21	.18449	.028507	.26221
22	.19023	.030766	.27296
23	.19587	.033100	.28370
24	.20141	.035511	.29442
25°	.20687	.038001	.30516
26	.21226	.040572	.31590
27	.21758	.043224	.32667
28	.22284	.045962	.33747
29	.22805	.048788	.34831
30	.23320	.051704	.35921
31	.23831	.054713	.37017
32	.24338	.057819	.38120
33	.24841	.061026	.39232
34	.25341	.064337	.40352
35	.25839	.067756	.41483
36	.26334	.071289	.42625
37	.26828	.074939	.43780
38	.27319	.078712	.44947
39	.27810	.082614	.46130
40	.28300	.086650	.47328
41	.28789	.090828	.48543
42	.29277	.095153	.49776
43	.29766	.099633	.51029
44	.30256	.104275	.52303
45	.30745	.109089	.53599

γ = 4.6

φ	X	Y	T
3°	.07575	.002260	.06255
2	.04280	.000802	.03858
+1	.01908	.000172	.01825
	+	+	+
0	.00000	.000000	.00000
	−	+	−
−1	.01622	.000138	.01682
2	.03046	.000509	.03259
3	.04324	.001065	.04754
4	.05490	.001777	.06182
5	.06565	.002621	.07557
6	.07566	.003585	.08885
7	.08507	.004656	.10175
8	.09395	.005825	.11430
9	.10239	.007085	.12657
10	.11043	.008431	.13859
11	.11814	.009859	.15038
12	.12555	.011365	.16198
13	.13268	.012947	.17342
14	.13958	.014603	.18470
15	.14627	.016332	.19586

γ = 4.6

φ	X	Y	T
16°	.15276	.018133	.20691
17	.15908	.020005	.21786
18	.16525	.021947	.22874
19	.17127	.023961	.23954
20	.17716	.026047	.25030
21	.18293	.028205	.26101
22	.18859	.030435	.27170
23	.19416	.032741	.28236
24	.19964	.035121	.29302
25	.20503	.037580	.30369
26	.21035	.040117	.31437
27	.21560	.042736	.32507
28	.22079	.045439	.33580
29	.22593	.048228	.34657
30	.23102	.051106	.35740
31	.23606	.054076	.36829
32	.24106	.057141	.37924
33	.24603	.060305	.39028
34	.25097	.063572	.40142
35	.25588	.066946	.41265
36	.26076	.070431	.42399
37	.26563	.074033	.43546
38	.27048	.077755	.44706
39	.27532	.081604	.45880
40	.28015	.085586	.47070
41	.28497	.089706	.48277
42	.28979	.093972	.49502
43	.29461	.098391	.50746
44	.29944	.102970	.52011
45	.30427	.107717	.53298

γ = 4.7

φ	X	Y	T
3°	.07682	.002304	.06295
2	.04304	.000808	.03869
+1	.01912	.000172	.01827
	+	+	+
0	.00000	.000000	.00000
	−	+	−
−1	.01619	.000138	.01681
2	.03038	.000507	.03255
3	.04309	.001060	.04745
4	.05467	.001766	.06170
5	.06534	.002606	.07539
6	.07528	.003562	.08862

γ = 4.7

φ	X	Y	T
7°	.08460	.004623	.10146
8	.09340	.005781	.11396
9	.10176	.007029	.12617
10	.10972	.008362	.13812
11	.11735	.009775	.14985
12	.12468	.011265	.16139
13	.13174	.012830	.17276
14	.13856	.014468	.18399
15	.14517	.016177	.19508
16	.15159	.017958	.20607
17	.15784	.019808	.21696
18	.16393	.021728	.22777
19	.16988	.023718	.23851
20	.17570	.025779	.24920
21	.18140	.027911	.25985
22	.18700	.030114	.27047
23	.19249	.032391	.28108
24	.19790	.034743	.29167
25	.20323	.037170	.30227
26	.20848	.039676	.31288
27	.21367	.042263	.32351
28	.21879	.044931	.33417
29	.22386	.047684	.34488
30	.22888	.050526	.35563
31	.23386	.053457	.36645
32	.23880	.056483	.37734
33	.24370	.059606	.38831
34	.24858	.062831	.39937
35	.25342	.066161	.41053
36	.25824	.069600	.42180
37	.26305	.073154	.43319
38	.26783	.076828	.44471
39	.27261	.080626	.45637
40	.27737	.084554	.46819
41	.28213	.088620	.48018
42	.28689	.092828	.49234
43	.29165	.097187	.50470
44	.29641	.101704	.51727
45	.30117	.106388	.53005

γ = 4.8

φ	X	Y	T
3°	.07795	.002351	.06336
2	.04330	.000814	.03880
+1	.01916	.000173	.01828
	+	+	+

γ = 4.8				γ = 4.9			
φ	X	Y	T	φ	X	Y	T
0°	.00000	.000000	.00000	3°	.07915	.002400	.06380
				2	.04356	.000821	.03892
	—	+	—	+1	.01921	.000173	.01831
−1	.01617	.000138	.01679		+	+	+
2	.03030	.000506	.03250	0	.00000	.000000	.00000
3	.04294	.001056	.04737		—	+	—
4	.05445	.001758	.06157	−1	.01615	.000137	.01679
5	.06504	.002590	.07521	2	.03022	.000504	.03247
6	.07490	.003539	.08838	3	.04280	.001051	.04730
7	.08414	.004591	.10116	4	.05423	.001748	.06145
8	.09286	.005738	.11361	5	.06475	.002575	.07504
9	.10114	.006974	.12576	6	.07453	.003516	.08816
10	.10902	.008294	.13765	7	.08369	.004559	.10089
11	.11657	.009692	.14933	8	.09233	.005696	.11328
12	.12382	.011167	.16081	9	.10053	.006920	.12537
13	.13081	.012715	.17212	10	.10834	.008227	.13721
14	.13756	.014336	.18328	11	.11581	.009611	.14883
15	.14410	.016026	.19431	12	.12299	.011071	.16025
16	.15044	.017787	.20524	13	.12990	.012603	.17150
17	.15662	.019616	.21606	14	.13658	.014206	.18260
18	.16264	.021514	.22681	15	.14305	.015878	.19358
19	.16852	.023481	.23749	16	.14933	.017619	.20444
20	.17427	.025517	.24812	17	.15543	.019428	.21521
21	.17991	.027624	.25871	18	.16139	.021305	.22589
22	.18544	.029801	.26927	19	.16720	.023249	.23652
23	.19087	.032051	.27981	20	.17288	.025262	.24708
24	.19621	.034374	.29034	21	.17845	.027344	.25761
25	.20147	.036773	.30087	22	.18392	.029496	.26811
26	.20666	.039248	.31141	23	.18928	.031719	.27858
27	.21178	.041802	.32198	24	.19456	.034015	.28905
28	.21685	.044437	.33258	25	.19976	.036384	.29952
29	.22185	.047156	.34321	26	.20489	.038829	.31000
30	.22681	.049962	.35390	27	.20995	.041352	.32050
31	.23173	.052857	.36465	28	.21495	.043955	.33103
32	.23660	.055844	.37547	29	.21990	.046641	.34160
33	.24144	.058927	.38637	30	.22480	.049412	.35222
34	.24625	.062111	.39736	31	.22965	.052271	.36291
35	.25104	.065398	.40845	32	.23446	.055222	.37366
36	.25580	.068793	.41964	33	.23924	.058267	.38449
37	.26054	.072301	.43096	34	.24399	.061410	.39541
38	.26526	.075927	.44240	35	.24872	.064656	.40642
39	.26997	.079675	.45399	36	.25342	.068008	.41755
40	.27468	.083553	.46573	37	.25810	.071472	.42879
41	.27938	.087565	.47764	38	.26276	.075051	.44016
42	.28407	.091719	.48973	39	.26741	.078752	.45168
43	.28877	.096021	.50201	40	.27206	.082580	.46334
44	.29346	.100479	.51449	41	.27669	.086541	.47517
45	.29817	.105100	.52719	42	.28133	.090641	.48718

γ = 4.9

φ	X	Y	T
43°	.28596	.094887	.49938
44	.29060	.099287	.51178
45	.29524	.103848	.52440

γ = 5.0

φ	X	Y	T
3°	.08044	.002455	.06425
2	.04383	.000828	.03902
+1	.01925	.000174	.01832
	+	+	+
0	.000000	.000000	.00000
	—	+	—
−1	.01612	.000137	.01677
2	.03015	.000502	.03242
3	.04266	.001046	.04721
4	.05401	.001740	.06131
5	.06446	.002560	.07486
6	.07416	.003493	.08793
7	.08324	.004527	.10060
8	.09181	.005654	.11294
9	.09993	.006868	.12497
10	.10767	.008162	.13675
11	.11506	.009533	.14831
12	.12217	.010977	.15967
13	.12901	.012494	.17087
14	.13562	.014080	.18191
15	.14201	.015734	.19283
16°	.14822	.017456	.20363
17	.15426	.019245	.21434
18	.16015	.021101	.22497
19	.16590	.023024	.23553
20	.17152	.025014	.24604
21	.17703	.027072	.25650
22	.18243	.029200	.26694
23	.18773	.031397	.27735
24	.19295	.033665	.28776
25	.19809	.036007	.29816
26	.20315	.038423	.30858
27	.20816	.040916	.31902
28	.21310	.043488	.32949
29	.21798	.046142	.34000
30	.22282	.048879	.35056
31	.22762	.051703	.36118
32	.23237	.054618	.37186
33	.23709	.057626	.38263
34	.24179	.060730	.39348
35	.24645	.063936	.40443
36	.25109	.067247	.41548
37	.25571	.070667	.42666
38	.26032	.074202	.43796
39	.26491	.077857	.44940
40	.26950	.081637	.46099
41	.27408	.085548	.47275
42	.27865	.089596	.48468
43	.28323	.093789	.49680
44	.28781	.098133	.50913
45	.29239	.102636	.52167

VII. TABLE OF VALUES OF $h = \frac{1}{2} g t^2 = 193.1447 t^2$ INCHES.

t	h	t	h	t	h	t	h
″	Inches.	″	Inches.	″	Inches.	″	Inches.
0.10	1.9314	0.21	8.5177	0.32	19.778	0.43	35.713
.11	2.3371	.22	9.3482	.33	21.034	.44	37.393
.12	2.7813	.23	10.217	.34	22.328	.45	39.112
.13	3.2641	.24	11.125	.35	23.660	.46	40.869
.14	3.7856	.25	12.072	.36	25.032	.47	42.666
.15	4.3458	.26	13.057	.37	26.442	.48	44.501
.16	4.9445	.27	14.080	.38	27.890	.49	46.374
.17	5.5819	.28	15.143	.39	29.377	.50	48.286
.18	6.2579	.29	16.244	.40	30.903	.51	50.237
.19	6.9725	.30	17.383	.41	32.468	.52	52.226
.20	7.7258	.31	18.561	.42	34.071	.53	54.254

VIII. A GENERAL TABLE OF VALUES OF $\frac{d^2}{w}s$ FOR OGIVAL HEADED SHOT.

V.	0	1	2	3	4	5	6	7	8	9
F-s.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
54	1 7303	7250	7197	7144	7092	7039	6987	6935	6883	6832
55	1 6780	6729	6678	6627	6577	6526	6476	6426	6376	6326
56	1 6276	6227	6178	6129	6080	6031	5982	5934	5886	5838
57	1 5790	5742	5695	5647	5600	5553	5506	5459	5413	5366
58	1 5320	5274	5228	5182	5137	5091	5046	5001	4956	4911
59	1 4866	4822	4777	4733	4689	4645	4601	4558	4514	4471
60	1 4428	4385	4342	4299	4256	4214	4171	4129	4087	4045
61	1 4003	3962	3920	3879	3838	3796	3755	3714	3674	3633
62	1 3593	3552	3512	3472	3432	3392	3353	3313	3274	3234
63	1 3195	3156	3117	3079	3040	3001	2963	2925	2886	2848
64	1 2810	2772	2735	2697	2660	2622	2585	2548	2511	2474
65	1 2437	2400	2364	2327	2291	2255	2218	2182	2146	2111
66	1 2075	2039	2004	1969	1933	1898	1863	1828	1793	1758
67	1 1724	1689	1655	1620	1586	1552	1518	1484	1450	1417
68	1 1383	1349	1316	1283	1250	1216	1183	1150	1118	1085
69	1 1052	1019	0987	0955	0922	0890	0858	0826	0794	0762
70	1 0731	0699	0667	0636	0605	0573	0542	0511	0480	0449
71	1 0418	0387	0357	0326	0296	0265	0235	0205	0174	0144
72	1 0114	0084	0055	0025	9995	9966	9936	9907	9877	9848
73	9819	9790	9761	9732	9703	9674	9646	9617	9588	9560
74	9531	9503	9475	9447	9419	9391	9363	9335	9307	9279
75	9252	9224	9197	9169	9142	9115	9087	9060	9033	9006
76	8979	8952	8926	8899	8872	8846	8819	8793	8766	8740
77	8714	8688	8662	8636	8610	8584	8558	8532	8507	8481
78	8455	8430	8404	8354	8379	8329	8303	8278	8253	8228
79	8203	8179	8154	8129	8104	8080	8055	8031	8006	7982
80	7958	7934	7909	7885	7861	7837	7813	7789	7766	7742
81	7718	7694	7671	7647	7624	7600	7577	7554	7531	7507
82	7484	7461	7438	7415	7392	7369	7347	7324	7301	7279
83	7256	7234	7211	7189	7166	7144	7122	7100	7078	7055
84	7033	7011	6990	6968	6946	6924	6902	6881	6859	6837
85	6816	6794	6773	6752	6730	6709	6688	6667	6646	6625
86	6604	6583	6562	6541	6520	6499	6478	6458	6437	6417
87	6396	6375	6355	6335	6314	6294	6274	6254	6233	6213
88	6193	6173	6153	6133	6113	6093	6074	6054	6034	6014
89	5995	5975	5956	5936	5917	5897	5878	5859	5839	5820
90	5801	5782	5763	5744	5725	5706	5687	5668	5649	5631
91	5612	5593	5575	5556	5538	5519	5501	5483	5464	5446
92	5428	5410	5392	5374	5356	5338	5321	5303	5285	5268
93	5250	5232	5215	5198	5180	5163	5146	5129	5111	5094
94	5077	5060	5044	5027	5010	4993	4976	4960	4943	4927
95	4910	4894	4847	4861	4845	4829	4812	4796	4780	4764
96	4749	4733	4717	4701	4686	4670	4654	4639	4624	4608
97	4593	4578	4562	4547	4532	4517	4502	4487	4473	4458
98	4443	4429	4414	4399	4385	4371	4356	4342	4328	4314

V.	0	1	2	3	4	5	6	7	8	9
F-s.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
99	4300	4285	4271	4258	4244	4230	4216	4203	4189	4176
100	4162	4149	4136	4123	4110	4097	4084	4071	4058	4045
101	4033	4020	4008	3995	3983	3970	3958	3946	3934	3921
102	3910	3898	3886	3874	3863	3851	3840	3829	3817	3806
103	3795	3784	3773	3762	3751	3740	3730	3719	3708	3698
104	3687	3677	3666	3656	3646	3636	3626	3616	3606	3596
105	3586	3576	3567	3557	3547	3538	3528	3519	3510	3501
106	3491	3482	3473	3464	3455	3446	3438	3429	3420	3411
107	3402	3394	3385	3377	3368	3360	3351	3343	3334	3326
108	3318	3310	3301	3293	3285	3277	3269	3261	3252	3244
109	3236	3228	3220	3213	3205	3197	3189	3181	3173	3165
110	3158	3150	3142	3134	3127	3119	3111	3103	3096	3088
111	3080	3073	3065	3058	3050	3043	3035	3028	3020	3013
112	3005	2998	2990	2983	2976	2968	2961	2953	2946	2939
113	2931	2924	2917	2910	2902	2895	2888	2881	2874	2867
114	2859	2852	2845	2838	2831	2824	2817	2810	2803	2796
115	2789	2782	2775	2768	2761	2754	2747	2740	2733	2727
116	2720	2713	2706	2699	2692	2686	2679	2672	2665	2659
117	2652	2645	2638	2632	2625	2618	2612	2605	2598	2592
118	2585	2579	2572	2566	2559	2552	2546	2539	2533	2526
119	2520	2513	2507	2500	2494	2488	2481	2475	2468	2462
120	2456	2449	2443	2436	2430	2424	2417	2411	2405	2399
121	2392	2386	2380	2374	2367	2361	2355	2349	2342	2336
122	2330	2324	2318	2312	2306	2299	2293	2287	2281	2275
123	2269	2263	2257	2251	2245	2239	2233	2227	2221	2215
124	2209	2203	2197	2191	2185	2179	2173	2167	2161	2155
125	2149	2143	2138	2132	2126	2120	2114	2108	2102	2097
126	2091	2085	2079	2073	2068	2062	2056	2050	2045	2039
127	2033	2028	2022	2016	2011	2005	1999	1994	1988	1982
128	1977	1971	1965	1960	1954	1948	1943	1937	1932	1926
129	1921	1915	1909	1904	1898	1893	1887	1882	1876	1871
130	1865	1860	1854	1849	1844	1838	1833	1827	1822	1816
131	1811	1806	1800	1795	1789	1784	1779	1773	1768	1762
132	1757	1752	1746	1741	1736	1730	1725	1720	1715	1709
133	1704	1699	1693	1688	1683	1678	1672	1667	1662	1657
134	1651	1646	1641	1636	1631	1625	1620	1615	1610	1605
135	1599	1594	1589	1584	1579	1574	1569	1564	1558	1553
136	1548	1543	1538	1533	1528	1523	1518	1513	1508	1503
137	1498	1493	1488	1483	1477	1472	1467	1462	1457	1452
138	1447	1442	1437	1432	1427	1422	1418	1413	1408	1403
139	1398	1393	1388	1383	1378	1373	1368	1363	1358	1353
140	1348	1344	1339	1334	1329	1324	1319	1314	1309	1304
141	1300	1295	1290	1285	1280	1275	1270	1266	1261	1256
142	1251	1246	1242	1237	1232	1227	1222	1217	1213	1208
143	1203	1198	1193	1189	1184	1179	1174	1170	1165	1160
144	1155	1151	1146	1141	1136	1132	1127	1122	1118	1113
145	1108	1103	1099	1094	1089	1085	1080	1075	1070	1066
146	1061	1056	1052	1047	1042	1038	1033	1028	1024	1019
147	1014	1010	1005	1001	996	991	987	982	977	973
148	968	963	959	954	950	945	940	936	931	927
149	922	917	913	908	904	899	894	890	885	881

V.	0	1	2	3	4	5	6	7	8	9
F-s.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet
150	876	871	867	862	858	853	849	844	840	835
151	830	826	821	817	812	808	803	799	794	790
152	785	781	776	771	767	762	758	753	749	744
153	740	735	731	726	722	717	713	708	704	699
154	695	690	686	681	676	672	668	663	659	654
155	650	645	641	637	632	628	623	619	614	610
156	605	601	596	592	588	583	579	574	570	565
157	561	556	552	548	543	539	534	530	525	521
158	516	512	508	503	499	494	490	486	481	477
159	472	468	464	459	455	450	446	442	437	433
160	428	424	420	415	411	406	402	398	393	389
161	385	380	376	371	367	363	358	354	350	345
162	341	337	332	328	324	319	315	310	306	302
163	297	293	289	284	280	276	271	267	263	258
164	254	250	245	241	237	232	228	224	220	215
165	211	207	202	198	194	189	185	181	177	172
166	168	164	160	155	151	147	142	138	134	130
167	126	121	117	113	109	104	100	96	92	88
168	83	79	75	71	67	62	58	54	50	46
169	41	37	33	29	25	21	17	12	8	4

IX. A GENERAL TABLE OF VALUES OF $\frac{d^2}{w}t$ FOR OGIVAL HEADED SHOT.

V.	0	1	2	3	4	5	6	7	8	9
F-s.	Seconds.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs	Secs	Secs.	Secs.
54	22.078	*.980	*.882	*.784	*.688	*.592	*.496	*.401	*.306	*.212
55	21.118	.025	*.933	*.841	*.749	*.658	*.567	*.477	*.388	*.299
56	20.210	.122	.034	*.947	*.860	*.774	*.688	*.603	*.518	*.433
57	19.349	.265	.182	.099	.017	*.935	*.854	*.773	*.692	*.612
58	18.532	.453	.374	.295	.217	.139	.062	*.985	*.908	*.832
59	17.756	.681	.606	.531	.457	.383	.309	.236	.163	.091
60	17.019	*.947	*.876	*.805	*.734	*.664	*.594	*.524	*.455	*.386
61	16.318	.249	.182	.114	.047	*.980	*.913	*.847	*.781	*.715
62	15.650	.585	.520	.456	.392	.328	.265	.201	.139	.076
63	15.014	*.952	*.890	*.829	*.768	*.707	*.647	*.586	*.526	*.467
64	14.407	.348	.290	.231	.173	.115	.057	*.999	*.942	*.885
65	13.829	.772	.716	.660	.605	.549	.494	.439	.385	.330
66	13.276	.222	.168	.115	.062	.009	*.956	*.904	*.852	*.800
67	12.748	.696	.645	.594	.543	.493	.442	.392	.342	.292
68	12.243	.194	.145	.096	.047	*.999	*.950	*.903	*.855	*.807
69	11.760	.713	.666	.619	.572	.526	.480	.434	.388	.343
70	11.297	.252	.207	.162	.118	.073	.029	*.985	*.941	*.898
71	10.854	.811	.768	.725	.682	.639	.597	.555	.513	.471

V.	0	1	2	3	4	5	6	7	8	9
F-s.	Seconds.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.
72	10.429	.388	.346	.305	.264	.223	.183	.142	.102	.062
73	10.022	*.982	*.942	*.903	*.863	*.824	*.785	*.746	*.708	*.669
74	9.631	.592	.554	.516	.478	.441	403	.366	.329	.292
75	9.255	.218	.182	.145	.109	.073	.037	.001	*.965	*.930
76	8.894	.859	.824	.789	.754	.719	.684	.650	.616	.581
77	8.547	.513	.480	.446	.412	.379	.346	.312	.279	.246
78	8.214	.181	.148	.116	.084	.052	.020	*.988	*.956	*.924
79	7.893	.861	.830	.799	.768	.737	.706	.675	.645	.614
80	7.584	.553	.523	.493	.463	.453	.404	.374	.345	.315
81	7.286	.257	.228	.199	.170	.141	.113	.084	.056	.027
82	6.999	.971	.943	.915	.887	.859	.832	.804	.777	.750
83	6.722	.695	.668	.641	.615	.588	.561	.535	.508	.482
84	6.456	.430	.404	.378	.352	.326	.300	.275	.249	.224
85	6.198	.173	.148	.123	.098	.073	.048	.024	*.999	*.974
86	5.950	.926	.901	.877	.853	.829	.805	.781	.757	.734
87	5.710	.686	.663	.640	.616	.593	.570	.547	.524	.501
88	5.478	.455	.433	.410	.388	.365	.343	.321	.298	.276
89	5.254	.232	.210	.188	.167	.145	.123	.102	.080	.059
90	5.038	.016	*.995	*.974	*.953	*.932	*.911	*.890	*.870	*.849
91	4.829	.808	.788	.768	.747	.727	.707	.687	.667	.648
92	4.628	.608	.589	.569	.550	.531	.511	.492	.473	.454
93	4.435	.417	.398	.379	.361	.342	.324	.305	.287	.269
94	4.251	.233	.215	.197	.179	.161	.144	.126	.109	.091
95	4.074	.057	.039	.022	.005	*.988	*.971	*.955	*.938	*.921
96	3.905	.888	.872	.856	.839	.823	.807	.791	.775	.759
97	3.743	.728	.712	.697	.681	.666	.650	.635	.620	.605
98	3.590	.575	.560	.546	.531	.516	.502	.487	.473	.459
99	3.444	.430	.416	.402	.389	.375	.361	.347	.334	.320
100	3.307	.294	.281	.267	.254	.241	.229	.216	.203	.190
101	3.178	.165	.153	.141	.128	.116	.104	.092	.080	.069
102	3.057	.045	.034	.022	.011	*.999	*.988	*.977	*.966	*.955
103	2.944	.933	.922	.911	.901	.890	.880	.869	.859	.849
104	2.839	.829	.819	.809	.799	.789	.780	.770	.761	.751
105	2.742	.733	.724	.714	.705	.696	.687	.679	.670	.661
106	2.652	.644	.635	.627	.618	.610	.602	.593	.585	.577
107	2.569	.561	.553	.545	.537	.529	.521	.513	.505	.498
108	2.490	.482	.475	.467	.459	.452	.444	.437	.430	.422
109	2.415	.407	.400	.393	.386	.378	.371	.364	.357	.350
110	2.343	.336	.329	.321	.314	.307	.301	.294	.287	.280
111	2.273	.266	.259	.252	.246	.239	.232	.225	.219	.212
112	2.205	.199	.192	.186	.179	.172	.166	.159	.153	.146
113	2.140	.134	.127	.121	.114	.108	.102	.095	.089	.083
114	2.076	.070	.064	.058	.052	.045	.039	.033	.027	.021
115	2.015	.009	.003	*.997	*.991	*.985	*.979	*.973	*.967	*.961
116	1.955	.949	.943	.937	.931	.926	.920	.914	.908	.902
117	1.897	.891	.885	.880	.874	.868	.863	.857	.851	.846
118	1.840	.834	.829	.823	.818	.812	.807	.801	.796	.790
119	1.785	.779	.774	.768	.763	.758	.752	.747	.742	.736

V.	0	1	2	3	4	5	6	7	8	9
F-s.	Seconds.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs
120	1.731	.726	.720	.715	.710	.705	.699	.694	.689	.684
121	1.678	.673	.668	.663	.658	.653	.648	.642	.637	.632
122	1.627	.622	.617	.612	.607	.602	.597	.592	.587	.582
123	1.577	.572	.568	.563	.558	.553	.548	.543	.538	.533
124	1.529	.524	.519	.514	.509	.505	.500	.495	.490	.486
125	1.481	.476	.471	.467	.462	.457	.453	.448	.444	.439
126	1.434	.430	.425	.420	.416	.411	.407	.402	.398	.393
127	1.389	.384	.380	.375	.371	.366	.362	.357	.353	.349
128	1.344	.340	.335	.331	.327	.322	.318	.314	.309	.305
129	1.301	.296	.292	.288	.284	.279	.275	.271	.267	.262
130	1.258	.254	.250	.245	.241	.237	.233	.229	.225	.220
131	1.216	.212	.208	.204	.200	.196	.192	.188	.184	.179
132	1.175	.171	.167	.163	.159	.155	.151	.147	.143	.139
133	1.135	.131	.127	.123	.120	.116	.112	.108	.104	.100
134	1.096	.092	.088	.084	.081	.077	.073	.069	.065	.061
135	1.058	.054	.050	.046	.042	.039	.035	.031	.027	.023
136	1.020	.016	.012	.008	.005	.001	*.997	*.994	*.990	*.986
137	0.982	.979	.975	.971	.968	.964	.961	.957	.953	.950
138	.946	.942	.939	.935	.932	.928	.924	.921	.917	.914
139	.910	.907	.903	.899	.896	.892	.889	.885	.882	.878
140	.875	.871	.868	.864	.861	.857	.854	.850	.847	.843
141	.840	.836	.833	.830	.826	.823	.819	.816	.813	.809
142	.806	.802	.799	.796	.792	.789	.785	.782	.779	.775
143	.772	.769	.765	.762	.759	.755	.752	.749	.745	.742
144	.739	.736	.732	.729	.726	.722	.719	.716	.713	.709
145	.706	.703	.700	.696	.693	.690	.687	.683	.680	.677
146	.674	.671	.667	.664	.661	.658	.655	.651	.648	.645
147	.642	.639	.636	.632	.629	.626	.623	.620	.617	.614
148	.610	.607	.604	.601	.598	.595	.592	.589	.586	.583
149	.579	.576	.573	.570	.567	.564	.561	.558	.555	.552
150	.549	.546	.543	.540	.537	.534	.531	.528	.524	.521
151	.518	.515	.512	.509	.506	.503	.500	.497	.494	.491
152	.488	.485	.482	.480	.477	.474	.471	.468	.465	.462
153	.459	.456	.453	.450	.447	.444	.441	.438	.435	.432
154	.429	.427	.424	.421	.418	.415	.412	.409	.406	.403
155	.400	.398	.395	.392	.389	.386	.383	.380	.377	.375
156	.372	.369	.366	.363	.360	.358	.355	.352	.349	.346
157	.343	.341	.338	.335	.332	.329	.326	.324	.321	.318
158	.315	.312	.310	.307	.304	.301	.298	.296	.293	.290
159	.287	.285	.282	.279	.276	.274	.271	.268	.265	.263
160	.260	.257	.254	.252	.249	.246	.243	.241	.238	.235
161	.232	.230	.227	.224	.222	.219	.216	.214	.211	.208
162	.205	.203	.200	.197	.195	.192	.189	.187	.184	.181
163	.179	.176	.173	.171	.168	.165	.163	.160	.157	.155
164	.152	.150	.147	.144	.142	.139	.136	.134	.131	.129
165	.126	.123	.121	.118	.116	.113	.110	.108	.105	.103
166	.100	.097	.095	.092	.090	.087	.085	.082	.080	.077
167	.075	.072	.070	.067	.064	.062	.059	.057	.054	.052
168	.049	.047	.044	.042	.039	.037	.034	.032	.029	.027
169	.024	.022	.020	.017	.015	.012	.010	.007	.005	.002

X. A GENERAL TABLE OF VALUES OF $\frac{d^2}{w}s$ FOR SPHERICAL SHOT.

V.	0	1	2	3	4	5	6	7	8	9
F. s.	Feet.	Feet	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
50	10649	0620	0592	0563	0535	0506	0478	0450	0422	0394
51	10366	0338	0310	0283	0255	0228	0201	0174	0147	0120
52	10093	0066	0040	0013	9987	9961	9935	9909	9883	9857
53	9831	9805	9779	9754	9729	9703	9678	9653	9628	9603
54	9578	9553	9529	9504	9480	9455	9431	9407	9383	9359
55	9335	9311	9287	9263	9240	9216	9193	9169	9146	9123
56	9100	9077	9054	9031	9008	8986	8963	8941	8918	8896
57	8873	8851	8829	8807	8785	8763	8741	8719	8698	8676
58	8655	8633	8612	8591	8569	8548	8527	8506	8485	8464
59	8443	8423	8402	8381	8361	8340	8320	8300	8279	8259
60	8239	8219	8199	8179	8159	8139	8120	8100	8081	8061
61	8041	8022	8003	7983	7964	7945	7926	7907	7888	7869
62	7850	7832	7813	7794	7776	7757	7739	7720	7702	7683
63	7665	7647	7629	7611	7593	7575	7557	7539	7521	7504
64	7486	7468	7451	7433	7416	7398	7381	7364	7346	7329
65	7312	7295	7278	7261	7244	7227	7210	7194	7177	7160
66	7144	7127	7110	7094	7078	7061	7045	7029	7012	6996
67	6980	6964	6948	6932	6916	6900	6884	6868	6853	6837
68	6821	6806	6790	6775	6759	6744	6728	6713	6698	6682
69	6667	6652	6637	6622	6607	6592	6577	6562	6547	6532
70	6517	6503	6488	6473	6459	6444	6430	6415	6401	6386
71	6372	6358	6343	6329	6315	6301	6287	6273	6259	6245
72	6231	6217	6203	6189	6175	6161	6148	6134	6120	6107
73	6093	6079	6066	6052	6039	6026	6012	5999	5986	5972
74	5959	5946	5933	5920	5907	5894	5881	5868	5855	5842
75	5829	5816	5803	5790	5778	5765	5752	5740	5727	5714
76	5702	5689	5677	5665	5652	5640	5627	5615	5603	5591
77	5578	5566	5554	5542	5530	5518	5506	5494	5482	5470
78	5458	5446	5434	5423	5411	5399	5387	5376	5364	5352
79	5341	5329	5318	5306	5295	5283	5272	5260	5249	5238
80	5226	5215	5204	5193	5181	5170	5159	5148	5137	5126
81	5115	5104	5093	5082	5071	5060	5049	5038	5027	5017
82	5006	4995	4984	4974	4963	4952	4942	4931	4921	4910
83	4900	4889	4879	4868	4858	4847	4837	4827	4817	4806
84	4796	4786	4776	4765	4755	4745	4735	4725	4715	4705
85	4695	4685	4675	4665	4655	4645	4635	4625	4615	4605
86	4596	4586	4576	4566	4557	4547	4537	4528	4518	4509
87	4499	4490	4480	4471	4461	4452	4442	4433	4423	4414
88	4405	4395	4386	4377	4367	4358	4349	4340	4331	4321
89	4312	4303	4294	4285	4276	4267	4258	4249	4240	4231
90	4222	4213	4204	4195	4186	4177	4169	4160	4151	4142
91	4134	4125	4116	4107	4099	4090	4081	4073	4064	4056

V.	0	1	2	3	4	5	6	7	8	9
F-s.	Feet.	Feet.	Feet.	Feet.	Feet,	Feet.	Feet.	Feet.	Feet.	Feet.
92	4047	4039	4030	4022	4013	4005	3996	3988	3980	3971
93	3963	3954	3946	3938	3930	3921	3913	3905	3897	3888
94	3880	3872	3864	3856	3848	3840	3832	3823	3815	3807
95	3799	3791	3784	3776	3768	3760	3752	3744	3736	3728
96	3721	3713	3705	3697	3689	3682	3674	3666	3659	3651
97	3643	3636	3628	3621	3613	3606	3598	3591	3583	3576
98	3568	3561	3553	3546	3539	3531	3524	3516	3509	3502
99	3495	3487	3480	3473	3466	3458	3451	3444	3437	3430
100	3423	3416	3409	3402	3395	3388	3381	3374	3367	3360
101	3353	3346	3339	3332	3325	3319	3312	3305	3298	3291
102	3285	3278	3271	3265	3258	3251	3245	3238	3231	3225
103	3218	3212	3205	3199	3192	3186	3179	3173	3166	3160
104	3154	3147	3141	3135	3128	3122	3116	3109	3103	3097
105	3091	3084	3078	3072	3066	3060	3054	3048	3041	3035
106	3029	3023	3017	3011	3005	2999	2993	2987	2982	2976
107	2970	2964	2958	2952	2946	2941	2935	2929	2923	2918
108	2912	2906	2900	2895	2889	2883	2878	2872	2866	2861
109	2855	2850	2844	2838	2833	2827	2822	2816	2811	2805
110	2800	2794	2789	2784	2778	2773	2767	2762	2757	2751
111	2746	2741	2735	2730	2725	2719	2714	2709	2704	2698
112	2693	2688	2683	2678	2672	2667	2662	2657	2652	2646
113	2641	2636	2631	2626	2621	2616	2611	2606	2601	2596
114	2591	2586	2581	2576	2571	2566	2561	2556	2551	2547
115	2541	2536	2531	2526	2522	2517	2512	2507	2502	2497
116	2492	2487	2483	2478	2473	2468	2464	2459	2454	2449
117	2444	2440	2435	2430	2426	2421	2416	2411	2407	2402
118	2397	2393	2388	2383	2379	2374	2369	2365	2360	2356
119	2351	2346	2342	2337	2333	2328	2323	2319	2314	2310
120	2305	2301	2296	2292	2287	2283	2278	2274	2269	2265
121	2260	2256	2252	2247	2243	2238	2234	2229	2225	2220
122	2216	2212	2207	2203	2199	2194	2190	2185	2181	2177
123	2172	2168	2164	2159	2155	2151	2146	2142	2138	2134
124	2129	2125	2121	2116	2112	2108	2104	2099	2095	2091
125	2087	2082	2078	2074	2070	2066	2061	2057	2053	2049
126	2045	2040	2036	2032	2028	2024	2020	2015	2011	2007
127	2003	1999	1995	1991	1986	1982	1978	1974	1970	1966
128	1962	1958	1954	1949	1945	1941	1937	1933	1929	1925
129	1921	1917	1913	1909	1905	1901	1897	1893	1889	1885
130	1881	1877	1873	1869	1865	1861	1857	1853	1849	1845
131	1841	1837	1833	1829	1825	1821	1817	1813	1809	1806
132	1802	1798	1794	1790	1786	1782	1778	1774	1770	1766
133	1763	1759	1755	1751	1747	1743	1739	1736	1732	1728
134	1724	1720	1716	1713	1709	1705	1701	1697	1694	1690
135	1686	1682	1678	1675	1671	1667	1663	1660	1656	1652
136	1648	1645	1641	1637	1633	1630	1626	1622	1618	1615
137	1611	1607	1603	1600	1596	1592	1589	1585	1581	1578
138	1574	1570	1567	1563	1559	1556	1552	1548	1545	1541
139	1537	1534	1530	1526	1523	1519	1516	1512	1508	1505
140	1501	1497	1494	1490	1487	1483	1479	1476	1472	1469
141	1465	1461	1458	1454	1451	1447	1444	1440	1437	1433

V.	0	1	2	3	4	5	6	7	8	9
F-s.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
142	1429	1426	1422	1419	1415	1412	1408	1405	1401	1398
143	1394	1391	1387	1384	1380	1377	1373	1370	1366	1363
144	1359	1356	1352	1349	1345	1342	1338	1335	1331	1328
145	1324	1321	1318	1314	1311	1307	1304	1300	1297	1293
146	1290	1287	1283	1280	1276	1273	1270	1266	1263	1259
147	1256	1253	1249	1246	1242	1239	1236	1232	1229	1225
148	1222	1219	1215	1212	1209	1205	1202	1199	1195	1192
149	1189	1185	1182	1179	1175	1172	1169	1165	1162	1159
150	1155	1152	1149	1145	1142	1139	1135	1132	1129	1126
151	1122	1119	1116	1112	1109	1106	1103	1099	1096	1093
152	1090	1086	1083	1080	1077	1073	1070	1067	1064	1060
153	1057	1053	1051	1047	1044	1041	1038	1034	1031	1028
154	1025	1022	1018	1015	1012	1009	1006	1002	999	996
155	993	990	987	983	980	977	974	971	968	964
156	961	958	955	952	949	945	942	939	936	933
157	930	927	924	920	917	914	911	908	905	902
158	899	895	892	889	886	883	880	877	874	871
159	868	864	861	858	855	852	849	846	843	840
160	837	834	831	828	825	822	818	815	812	809
161	806	803	800	797	794	791	788	785	782	779
162	776	773	770	767	764	761	758	755	752	749
163	746	743	740	737	734	731	728	725	722	719
164	716	713	710	707	704	701	698	695	692	689
165	686	683	680	677	674	672	669	666	663	660
166	657	654	651	648	645	642	639	636	633	630
167	628	625	622	619	616	613	610	607	604	601
168	598	596	593	590	587	584	581	578	575	572
169	569	567	564	561	558	555	552	549	546	544
170	541	538	535	532	529	526	524	521	518	515
171	512	509	506	504	501	498	495	492	489	487
172	484	481	478	475	472	470	467	464	461	458
173	456	453	450	447	444	442	439	436	433	430
174	428	425	422	419	416	414	411	408	405	402
175	400	397	394	391	389	386	383	380	377	375
176	372	369	366	364	361	358	355	353	350	347
177	344	342	339	336	333	331	328	325	322	320
178	317	314	311	309	306	303	301	298	295	292
179	290	287	284	282	279	276	273	271	268	265
180	263	260	257	255	252	249	246	244	241	238
181	236	233	230	228	225	222	220	217	214	212
182	209	206	204	201	198	196	193	190	188	185
183	182	180	177	174	172	169	166	164	161	158
184	156	153	150	148	145	143	140	137	135	132
185	129	127	124	122	119	116	114	111	108	106
186	103	101	98	95	93	90	88	85	82	80
187	77	75	72	69	67	64	62	59	57	54
188	51	49	46	44	41	39	36	33	31	28
189	26	23	21	18	15	13	10	7	5	3

XI. A GENERAL TABLE OF VALUES OF $\frac{d^2}{w}t$ FOR SPHERICAL SHOT.

V.	0	1	2	3	4	5	6	7	8	9
F-s.	Seconds.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.
50	13.414	.356	.299	.242	.185	.129	.073	.017	*.962	*.907
51	12.852	.798	.744	.690	.637	.584	.531	.478	.426	.374
52	12.323	.272	.221	.170	.119	.069	.020	*.970	*.921	*.872
53	11.823	.775	.726	.679	.631	.584	.537	.490	.443	.397
54	11.351	.305	.259	.214	.169	.124	.080	.036	*.991	*.948
55	10.904	.861	.818	.775	.732	.690	.647	.605	.564	.522
56	10.481	.440	.399	.358	.318	.278	.238	.198	.158	.119
57	10.080	.041	.002	*.964	*.926	*.887	*.849	*.812	*.774	*.737
58	9.700	.663	.626	.589	.553	.517	.481	.445	.409	.374
59	9.338	.303	.268	.234	.199	.165	.130	.096	.062	.029
60	8.995	.962	.929	.895	.863	.830	.797	.765	.733	.700
61	8.669	.637	.605	.574	.542	.511	.480	.449	.419	.388
62	8.358	.327	.297	.267	.237	.208	.178	.149	.120	.090
63	8.061	.033	.004	*.975	*.947	*.919	*.890	*.862	*.834	*.807
64	7.779	.752	.724	.697	.670	.643	.616	.589	.562	.536
65	7.510	.483	.457	.431	.405	.379	.354	.328	.303	.277
66	7.252	.227	.202	.177	.153	.128	.103	.079	.055	.030
67	7.006	*.982	*.958	*.935	*.911	*.887	*.864	*.841	*.817	*.794
68	6.771	.748	.725	.703	.680	.657	.635	.613	.590	.568
69	6.546	.524	.502	.481	.459	.437	.416	.394	.373	.352
70	6.331	.310	.289	.268	.247	.227	.206	.185	.165	.145
71	6.124	.104	.084	.064	.044	.025	.005	*.985	*.966	*.946
72	5.927	.907	.888	.869	.850	.831	.812	.793	.774	.756
73	5.737	.718	.700	.681	.663	.645	.627	.609	.591	.573
74	5.555	.537	.519	.502	.484	.466	.449	.432	.414	.397
75	5.380	.363	.346	.329	.312	.295	.278	.261	.245	.228
76	5.212	.195	.179	.163	.146	.130	.114	.098	.082	.066
77	5.050	.034	.019	.003	*.987	*.972	*.956	*.941	*.926	*.910
78	4.895	.880	.865	.849	.834	.819	.805	.790	.775	.760
79	4.745	.731	.716	.702	.687	.673	.659	.644	.630	.616
80	4.602	.587	.573	.559	.545	.532	.518	.504	.490	.476
81	4.463	.449	.436	.422	.409	.395	.382	.369	.356	.342
82	4.329	.316	.303	.290	.277	.264	.251	.239	.226	.213
83	4.200	.188	.175	.163	.150	.138	.125	.113	.101	.088
84	4.076	.064	.052	.040	.028	.016	.004	*.992	*.980	*.968
85	3.957	.945	.933	.921	.910	.898	.887	.875	.864	.852
86	3.841	.829	.818	.807	.796	.784	.773	.762	.751	.740
87	3.729	.718	.707	.696	.685	.675	.664	.653	.642	.632
88	3.621	.611	.600	.590	.579	.569	.558	.548	.537	.527
89	3.517	.507	.496	.486	.476	.466	.456	.446	.436	.426
90	3.416	.406	.396	.386	.377	.367	.357	.347	.338	.328
91	3.318	.309	.299	.290	.280	.271	.261	.252	.243	.233

V.	0	1	2	3	4	5	6	7	8	9
F-s.	Seconds.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.	Secs.
92	3.224	.215	.206	.196	.187	.178	.169	.160	.151	.142
93	3.133	.124	.115	.106	.097	.088	.079	.071	.062	.053
94	3.044	.036	.027	.019	.010	.001	*.993	*.984	*.976	*.967
95	2.959	.951	.942	.934	.926	.917	.909	.901	.893	.885
96	2.876	.868	.860	.852	.844	.836	.828	.820	.812	.804
97	2.797	.789	.781	.773	.765	.758	.750	.742	.734	.727
98	2.719	.712	.704	.697	.689	.682	.674	.667	.659	.652
99	2.645	.637	.630	.623	.616	.608	.601	.594	.587	.580
100	2.572	.565	.558	.551	.544	.537	.530	.523	.517	.510
101	2.503	.496	.489	.482	.476	.469	.462	.456	.449	.442
102	2.436	.429	.423	.416	.409	.403	.397	.390	.384	.377
103	2.371	.365	.358	.352	.346	.339	.333	.327	.321	.315
104	2.308	.302	.296	.290	.284	.278	.272	.266	.260	.254
105	2.248	.242	.236	.231	.225	.219	.213	.207	.202	.196
106	2.190	.184	.179	.173	.167	.162	.156	.151	.145	.140
107	2.134	.129	.123	.118	.112	.107	.102	.096	.091	.085
108	2.080	.075	.070	.064	.059	.054	.049	.043	.038	.033
109	2.028	.023	.018	.013	.008	.003	*.998	*.993	*.988	*.983
110	1.978	.973	.968	.963	.958	.953	.948	.943	.938	.933
111	1.929	.924	.919	.914	.910	.905	.900	.895	.891	.886
112	1.881	.877	.872	.867	.863	.858	.854	.849	.845	.840
113	1.835	.831	.826	.822	.817	.813	.808	.804	.800	.795
114	1.791	.786	.782	.778	.773	.769	.765	.760	.756	.752
115	1.747	.743	.739	.735	.730	.726	.722	.718	.714	.709
116	1.705	.701	.697	.693	.689	.684	.680	.676	.672	.668
117	1.664	.660	.656	.652	.648	.644	.640	.636	.632	.628
118	1.624	.620	.616	.612	.608	.604	.600	.596	.593	.589
119	1.585	.581	.577	.573	.569	.566	.562	.558	.554	.550
120	1.547	.543	.539	.535	.532	.528	.524	.520	.517	.513
121	1.509	.506	.502	498	.495	.491	.487	.484	.480	.476
122	1.473	.469	.466	.462	.459	.455	.451	.448	.444	.441
123	1.437	.434	.430	.427	.423	.420	.416	.413	.409	.406
124	1.402	.399	.395	.392	.388	.385	.382	.378	.375	.371
125	1.368	.365	.361	.358	.355	.351	.348	.344	.341	.338
126	1.334	.331	.328	.325	.321	.318	.315	.311	.308	.305
127	1.302	.298	.295	.292	.289	.285	.282	.279	.276	.272
128	1.269	.266	.263	.260	.257	.253	.250	.247	.244	.241
129	1.238	.234	.231	.228	.225	.222	.219	.216	.213	.210
130	1.206	.203	.200	.197	.194	.191	.188	.185	.182	.179
131	1.176	.173	.170	.167	.164	.161	.158	.155	.152	.149
132	1.146	.143	.140	.137	.134	.131	.128	.125	.122	.120
133	1.117	.114	.111	.108	.105	.102	.099	.096	.093	.091
134	1.088	.085	.082	.079	.076	.073	.071	.068	.065	.062
135	1.059	.057	.054	.051	.048	.045	.043	.040	.037	.034
136	1.032	.029	.026	.023	.020	.018	.015	.012	.010	.007
137	1.004	.001	*.999	*.996	*.993	*.991	*.988	*.985	*.983	*.980
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139	0.951	.948	.946	.943	.940	.938	.935	.933	.930	.927
140	0.925	.922	.920	.917	.915	.912	.909	.907	.904	.902
141	0.899	.897	.894	.892	.889	.887	.884	.882	.879	.877

t	0	1	2	3	4	5	6	7	8	9
"	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
5.1	418.6	420.3	421.9	423.6	425.2	426.9	428.5	430.2	431.9	433.5
5.2	435.2	436.9	438.6	440.3	442.0	443.6	445.3	447.0	448.7	450.4
5.3	452.1	453.8	455.5	457.3	458.9	460.7	462.4	464.1	465.9	467.6
5.4	469.3	471.1	472.8	474.6	476.3	478.1	479.8	481.6	483.4	485.1
5.5	486.9	488.6	490.4	492.2	494.0	495.8	497.6	499.4	501.2	503.0
5.6	504.8	506.6	508.4	510.2	512.0	513.8	515.6	517.5	519.3	521.1
5.7	522.9	524.8	526.6	528.5	530.4	532.2	534.0	535.8	537.7	539.6
5.8	541.4	543.3	545.2	547.1	549.0	550.8	552.7	554.6	556.5	558.4
5.9	560.3	562.2	564.1	566.0	567.9	569.8	571.7	573.7	575.6	577.5
6.0	579.4	581.4	583.3	585.2	587.2	589.1	591.1	593.0	595.0	597.0
6.1	598.9	600.9	602.9	604.8	606.8	608.8	610.7	612.7	614.7	616.7
6.2	618.7	620.7	622.7	624.7	626.7	628.7	630.7	632.8	634.8	636.8
6.3	638.8	640.9	642.9	644.9	647.0	649.0	651.1	653.1	655.2	657.2
6.4	659.3	661.3	663.4	665.5	667.5	669.6	671.7	673.8	675.9	677.9
6.5	680.0	682.1	684.2	686.3	688.4	690.5	692.6	694.8	696.9	699.0
6.6	701.1	703.3	705.4	707.5	709.7	711.8	713.9	716.1	718.2	720.4
6.7	722.5	724.7	726.8	729.0	731.2	733.4	735.5	737.7	739.9	742.1
6.8	744.3	746.4	748.6	750.8	753.0	755.2	757.5	759.7	761.9	764.1
6.9	766.3	768.5	770.8	773.0	775.2	777.4	779.7	781.9	784.2	786.4
7.0	788.7	790.9	793.2	795.4	797.7	800.0	802.3	804.5	806.8	809.1
7.1	811.4	813.7	816.0	818.2	820.5	822.8	825.1	827.5	829.8	832.1
7.2	834.4	836.7	839.0	841.3	843.7	846.0	848.4	850.7	853.0	855.4
7.3	857.7	860.1	862.4	864.8	867.1	869.5	871.9	874.3	876.6	879.0
7.4	881.4	883.8	886.2	888.5	890.9	893.3	895.7	898.1	900.6	903.0
7.5	905.4	907.8	910.2	912.6	915.1	917.5	919.9	922.4	924.8	927.2
7.6	929.7	932.1	934.6	937.0	939.5	941.9	944.4	946.9	949.3	951.8
7.7	954.3	956.8	959.3	961.8	964.2	966.7	969.2	971.7	974.2	976.7
7.8	979.2	981.8	984.3	986.8	989.3	991.8	994.4	996.9	999.4	100.2
7.9	1005	1007	1009	1012	1015	1017	1020	1023	1025	1028
8.0	1030	1033	1035	1038	1041	1043	1046	1048	1051	1053
8.1	1056	1059	1061	1064	1066	1069	1072	1074	1077	1080
8.2	1082	1085	1088	1090	1093	1095	1098	1101	1104	1106
8.3	1109	1112	1114	1117	1120	1122	1125	1128	1130	1133
8.4	1136	1138	1141	1144	1147	1149	1152	1155	1157	1160
8.5	1163	1166	1158	1171	1174	1177	1179	1182	1185	1188
8.6	1190	1193	1196	1199	1202	1204	1207	1210	1213	1216
8.7	1218	1221	1224	1227	1230	1232	1235	1238	1241	1244
8.8	1246	1249	1252	1255	1258	1261	1264	1266	1269	1272
8.9	1275	1278	1281	1284	1286	1289	1292	1295	1298	1301
9.0	1304	1307	1310	1312	1315	1318	1321	1324	1327	1330
9.1	1333	1336	1339	1342	1345	1348	1350	1353	1356	1359
9.2	1362	1365	1368	1371	1374	1377	1380	1383	1386	1389
9.3	1392	1395	1398	1401	1404	1407	1410	1413	1416	1419
9.4	1422	1425	1428	1431	1434	1437	1440	1444	1447	1450
9.5	1453	1456	1459	1462	1465	1468	1471	1474	1477	1480
9.6	1483	1486	1490	1493	1496	1499	1502	1505	1508	1511
9.7	1514	1518	1521	1524	1527	1530	1533	1536	1540	1543
9.8	1546	1549	1552	1555	1558	1562	1565	1568	1571	1574
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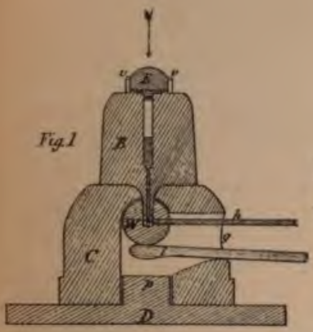
Fig. 1

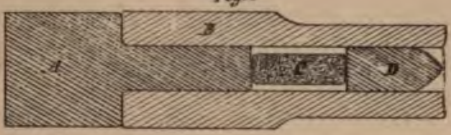
Fig. 2

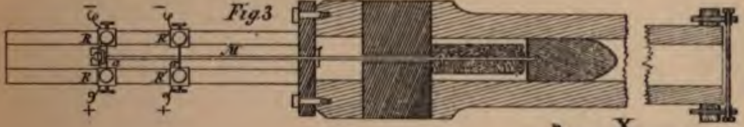
Fig. 3

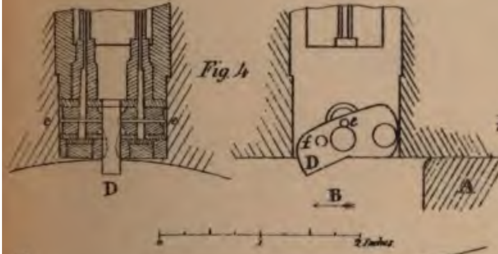
Fig. 4

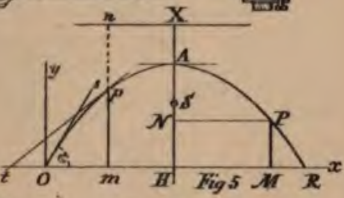
Fig. 5

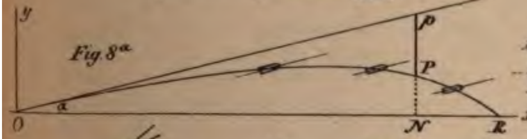
Fig. 8ª

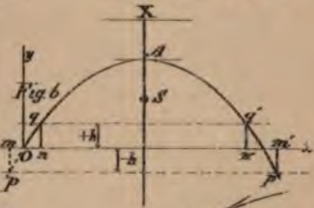
Fig. 6

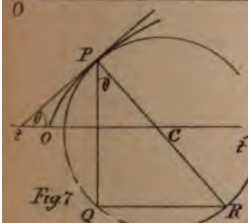
Fig. 7

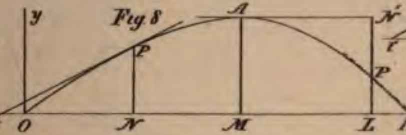
Fig. 8

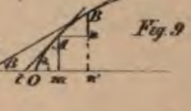
Fig. 9

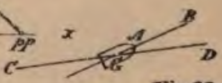
Fig. 9ª

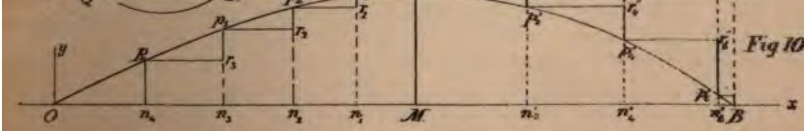
Fig. 10

SUPPLEMENT

TO A

MATHEMATICAL TREATISE

ON THE

MOTION OF PROJECTILES,

FOUNDED CHIEFLY ON THE

RESULTS OF EXPERIMENTS

MADE WITH

THE AUTHOR'S CHRONOGRAPH.

BY
FRANCIS BASHFORTH, B.D.,
LATE PROFESSOR OF APPLIED MATHEMATICS TO THE ADVANCED CLASS OF
ROYAL ARTILLERY OFFICERS, WOOLWICH, AND OFFICIAL REFEREE
TO THE LATE ORDNANCE SELECT COMMITTEE; AND
FORMERLY FELLOW OF ST. JOHN'S COLLEGE, CAMBRIDGE.

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BERLIN: 11, UNTER DEN LINDEN.
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t	0	1	2	3	4	5	6	7	8	9
–	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
5,1	418.6	420.3	421.9	423.6	425.2	426.9	428.5	430.2	431.9	433.5
5,2	435.2	436.9	438.6	440.3	441.9	443.6	445.3	447.0	448.7	450.4
5,3	452.1	453.8	455.5	457.3	459.0	460.7	462.4	464.1	465.9	467.6
5,4	469.3	471.1	472.8	474.6	476.3	478.1	479.8	481.6	483.4	485.1
5,5	486.9	488.7	490.4	492.2	494.0	495.8	497.6	499.4	501.2	503.0
5,6	504.8	506.6	508.4	510.2	512.0	513.8	515.6	517.5	519.3	521.1
5,7	522.9	524.8	526.6	528.5	530.3	532.2	534.0	535.8	537.7	539.6
5,8	541.4	543.3	545.2	547.1	549.0	550.8	552.7	554.6	556.5	558.4
5,9	560.3	562.2	564.1	566.0	567.9	569.8	571.7	573.7	575.6	577.5
6,0	579.4	581.4	583.3	585.2	587.2	589.1	591.1	593.0	595.0	597.0
6,1	598.9	600.9	602.9	604.8	606.8	608.8	610.7	612.7	614.7	616.7
6,2	618.7	620.7	622.7	624.7	626.7	628.7	630.7	632.8	634.8	636.8
6,3	638.8	640.9	642.9	644.9	647.0	649.0	651.1	653.1	655.2	657.2
6,4	659.3	661.3	663.4	665.5	667.5	669.6	671.7	673.8	675.9	677.9
6,5	680.0	682.1	684.2	686.3	688.4	690.5	692.6	694.8	696.9	699.0
6,6	701.1	703.3	705.4	707.5	709.7	711.8	713.9	716.1	718.2	720.4
6,7	722.5	724.7	726.8	729.0	731.2	733.4	735.5	737.7	739.9	742.1
6,8	744.3	746.4	748.6	750.8	753.0	755.2	757.5	759.7	761.9	764.1
6,9	766.3	768.5	770.8	773.0	775.2	777.4	779.7	781.9	784.2	786.4
7,0	788.7	790.9	793.2	795.4	797.7	800.0	802.3	804.5	806.8	809.1
7,1	811.4	813.7	816.0	818.2	820.5	822.8	825.1	827.5	829.8	832.1
7,2	834.4	836.7	839.0	841.3	843.7	846.0	848.4	850.7	853.0	855.4
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8,0	1030	1033	1035	1038	1041	1043	1046	1048	1051	1053
8,1	1056	1059	1061	1064	1066	1069	1072	1074	1077	1080
8,2	1082	1085	1088	1090	1093	1095	1098	1101	1104	1106
8,3	1109	1112	1114	1117	1120	1122	1125	1128	1130	1133
8,4	1136	1138	1141	1144	1147	1149	1152	1155	1157	1160
8,5	1163	1166	1158	1171	1174	1177	1179	1182	1185	1188
8,6	1190	1193	1196	1199	1202	1204	1207	1210	1213	1216
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8,8	1246	1249	1252	1255	1258	1261	1264	1266	1269	1272
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9,1	1333	1336	1339	1342	1345	1348	1350	1353	1356	1359
9,2	1362	1365	1368	1371	1374	1377	1380	1383	1386	1389
9,3	1392	1395	1398	1401	1404	1407	1410	1413	1416	1419
9,4	1422	1425	1428	1431	1434	1437	1440	1444	1447	1450
9,5	1453	1456	1459	1462	1465	1468	1471	1474	1477	1480
9,6	1483	1486	1490	1493	1496	1499	1502	1505	1508	1511
9,7	1514	1518	1521	1524	1527	1530	1533	1536	1540	1543
9,8	1546	1549	1552	1555	1558	1562	1565	1568	1571	1574
9,9	1578	1581	1584	1587	1590	1593	1597	1600	1603	1606

Fig. 1

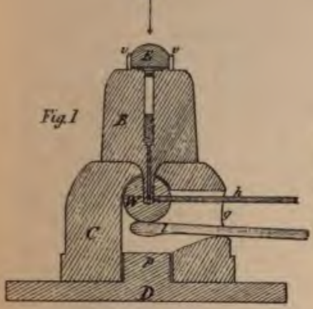


Fig. 2

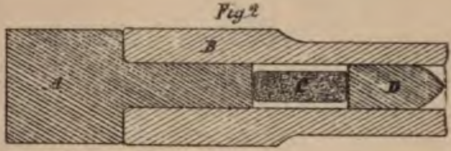


Fig. 3

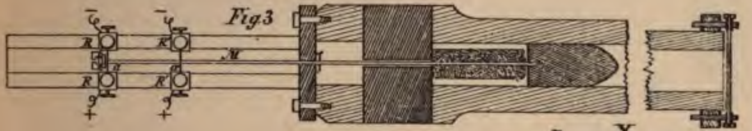


Fig. 4

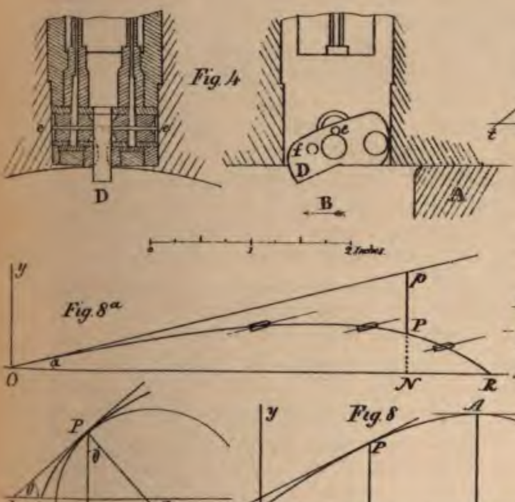


Fig 5

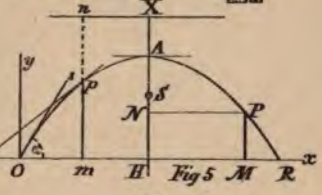


Fig. 6

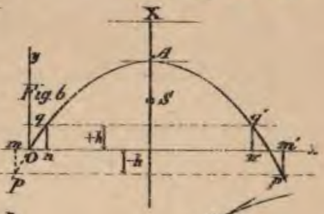


Fig. 8ª

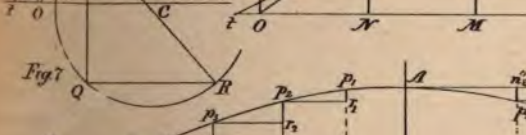


Fig. 9

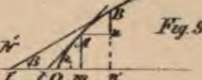


Fig. 7

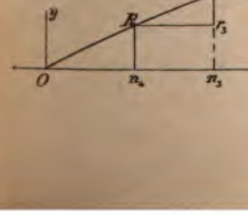


Fig. 8

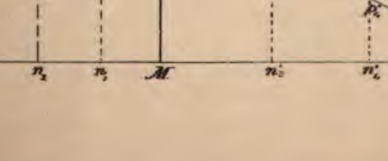


Fig. 9ª

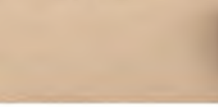
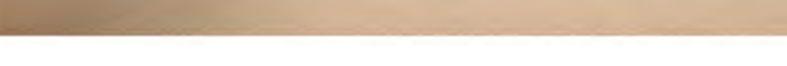


Fig 10



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SUPPLEMENT

TO

A TREATISE ON THE MOTION OF PROJECTILES,

BY

FRANCIS BASHFORTH, B.D.,

1881.

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91. *Preliminary Remarks.*] MY work, commenced in the Spring of 1864, is now brought to a conclusion. When the first part of this Treatise was published in 1873, the Advanced Class of Royal Artillery Officers was in a state of abeyance, as already explained, because there was not a sufficient number of candidates qualified for admission to form a new class. Some time before this, the Advanced Class had been frequently attacked in the newspapers, and a very distinguished Fellow of the Royal Society, who had nothing whatever to do with the matter, thought proper to join in the fray. Having attacked the Professor of Applied Mathematics, he concluded his diatribe with the remark "It is "high time that the guardians of the public purse should "set their faces against such vicious reproduction of fresh "nuclei of misapplied prodigality, surely destined to eventuate "(if I may apply the words of an eloquent member of the "deputation of which I formed a part) in endowed and "decorated idleness."—*The Times*, Feb. 11, 1870. The letter was characteristic and required no answer. If the reader be desirous of knowing more about the objections to the Advanced Class, or the schemes propounded for bettering it, he is referred to *Parliamentary Paper* 1872 [c. 589]. In spite of all opposition the Advanced Class was revived after an interval of upwards of two years, and I believe is now being conducted at Woolwich in very much the same manner as before the interruption.

It must be confessed that this turmoil, coming on so soon after the printing of my Reports of experiments made 1865—1870, did not afford me much encouragement in pursuing my self-imposed, and almost thankless work of making laborious experiments. And as I did not see that

I could succeed better than I had already done, I retired from my office of Professor of Applied Mathematics, because, if I was not to be engaged on original research, the reason for my connection with the Advanced Class ceased.

Subsequently I was informed that my results were being "tested" at Shoeburyness, and that it was intended to complete my work by making experiments with *low* velocities by the help of such chronoscopes as the Government possessed.

Although I had given up experimenting I continued to prepare tables, &c., at my leisure, with a view to render the application of my results already obtained to the calculation of trajectories, &c., as easy and simple as possible. In 1877 I proceeded to print the Supplementary Tables A. to G. But when my work had proceeded thus far, much to my surprise, I received an invitation to lend my chronograph and give my assistance in completing the experiments commenced about ten years before. It appeared to me that I ought to comply with this request because I had the means ready for the performance of the work, and because the invitation itself, under the circumstances, seemed to be a sufficient recognition of the practical value of my previous labours, and also a confession that, for that particular work, my chronograph was superior to all those possessed by Government and used more or less in their experiments. These were the new Ballistic Pendulum, the Navez, the Leurs, the Boulengé, and the Schultz Chronoscopes.

My instrument was therefore sent back to Shoeburyness and set up in June, 1878, having been removed from that place in May, 1870. These recent experiments were carried out with *very high* as well as *very low* velocities. The projectiles were ogival-headed, excepting three rounds of flat-headed and three rounds of hemispherical-headed shot, which gave very satisfactory results for each form of head through a considerable range of velocity. The reader is referred to the final Report on Experiments made with my chronograph 1878—1880 for all particulars respecting these late experiments. The chronograph has now been returned to the South Kensington Museum. In addition to the Officers of the Royal Artillery already mentioned, my thanks are due to the following Officers, who most carefully carried out all these recent experiments at Shoeburyness, and sent me the records for reduction, namely, Major C. Jones, R.A.; Captain Bainbridge, R.A.; Captain Morley, R.A.; Captain McClintock, R.A.; Captain O'Callaghan, R.A.; and Captain White, R.A.

After I had satisfied myself respecting the capabilities of my instrument in 1865, I was careful to refrain from doing anything which might prevent it from being applied to that purpose for which it was designed. Time has gradually removed obstructions and softened down asperities, and brought forward better instructed officers capable of forming an independent opinion in scientific matters. Thus, by working and waiting, the desired result has been arrived at at last. Every possible assistance has been most readily afforded me, so that for any deficiency I am alone responsible. I wish also to express my great obligation for the official publication of all my reports just as they were written* at the specified dates, for these speak for themselves. And it is a curious question why, when an instrument much wanted in the service had proved uniformly successful, the use of it was neglected, so that important results, which might have been easily obtained in three or four years, were delayed for fifteen years. These original Reports of my Experiments and my complete "Treatise on the Motion of Projectiles" being now before the world, I have every confidence that my labours will receive just that appreciation which they may be found to deserve.

92. The best evidence of the real opinion entertained of the value of my experiments will be found in the use that has been made of the results at home and abroad. After the trial of my instrument, the first real experiment was made to determine the resistance of the air to elongated projectiles provided with various forms of heads. The Report of this experiment was dated October, 1866.† By minute 23,351, September 21, 1867, the Ordnance Select Committee adopted my result as the produce of their own experiments, so far as Service Shot was concerned. The omitted acknowledgment was afterwards fully supplied in the *Proceedings of the O. S. C.* vol. VI. 397, 1868. My General Tables were reprinted in the new edition of the *Treatise on the Construction of Ordnance*, by Major John F. Owen, R.A., Captain Instructor, Royal Gun Factories; and again in *Principles of Gunnery, for the use of the R. M. Academy, Woolwich*, by

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* "Reports on Experiments made with the Bashforth Chronograph to determine the Resistance of the Air to the Motion of Projectiles, 1865—1870." London: W. Clowes and Son, Harrison and Sons, &c., &c.

And "Final Report on Experiments made with the Bashforth Chronograph to determine the Resistance of the Air to the Motion of Elongated Projectiles, 1878—1880." London: W. Clowes and Sons (Limited), Harrison and Sons, &c., 1880. Price Two Shillings and Threepence.

† *Reports, &c.*, p. 10, and *Phil. Trans.*, 1868.

Major Sladen, R.A., Professor of Artillery. Captain Kensington, R.A., contributed to the Proceedings of the Royal Artillery Institution some useful explanatory notes on the former part of this treatise. And more recently application has been made to me for assistance in the production of a Naval Manual of Gunnery. In Russia, General Mayevski, Professeur de Balistique à l'Académie d'Artillerie, adopted my results, so far as they were known to him, in his *Balistique Extérieure*, published in Russian in 1870 and in French in 1872. The following table has been copied from this work, concerning which General Mayevski remarks: "Aussi "pour compléter les données se rapportant aux projectiles "de forts calibres nous avons profité des tableaux des vitesses "décroissantes déduites par M. Bashforth de ses expériences "faites en 1868 au moyen de son chronographe; ces tableaux "comprennent les vitesses de $518^{m.s}$ à $283^{m.s}$ qui correspondent "aux trajets de 305 (30·5) en 305 (30·5) mètres des projectiles "oblongs de 178^{mm}, 203^{mm} et 229^{mm}, et qui sont obtenues "pour le cas où le mouvement des projectiles peut être considéré comme rectiligne. Nous avons calculé d'après les "résultats insérés dans ces tableaux les valeurs de la résistance "correspondantes à différentes vitesses."* Those determinations of ρ' marked "angl." were derived from my tables.

Projectiles Oblongs.†

Bouches à feu	Vitesses v	Valeurs de ρ'	Bouches à feu	Vitesses v	Valeurs de ρ'
C. de 4^{1}	$172^{m.s}$	0.0151	C. de 203^{mm}	$329^{m.s}$	0·0338
C. de 203^{mm}	207	0·0137	C. de 203^{mm} angl.	332	0·0327
C. de 4^{1}	239	0·0148	C. de 229^{mm} angl.	334	0·0332
C. de 12^{1}	247	0·0170	C. de 4^{1}	337	0·0341
C. de 24^{1}	266	0·0160	C. de 178^{mm} angl.	340	0·0334
C. de 203^{mm}	282	0·0163	C. de 203^{mm} angl.	345	0·0354
C. de 203^{mm} angl.	287	0·0184	C. de 229^{mm} angl.	355	0·0364
C. de 229^{mm} angl.	291	0 0247	C. de 178^{mm} angl.	358	0·0382
C. de 203^{mm} angl.	300	0·0230	C. de 203^{mm}	360	0·0384
C. de 178^{mm} angl.	302	0 0218	C. de 203^{mm} angl.	360	0·0393
C. de 12^{1}	304	0·0221	C. de 4^{1}	401	0·0450
C. de 4^{1}	307	0·0158	C. de 203^{mm}	409	0·0430
C. de 229^{mm} angl.	316	0·0305	C. de 203^{mm} angl.	419	0·0433
C. de 4^{1}	317	0·0259	C. de 229^{mm} angl.	420	0·0427
C. de 203^{mm}	319	0·0174	C. de 203^{mm} angl.	460	0·0449
C. de 203^{mm} angl.	320	0·0277	C. de 203^{mm} angl.	508	0·0440
C. de 24^{1}	320	0·0299	C. de 178^{mm} angl.	512	0·0443
C. de 178^{mm} angl.	322	0·0270			

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* Mayevski, *Balistque Extérieure*, 1872, p. 38. † *Ib.* p. 39.

General Mayevski plotted these results, taking the velocities for abscissæ, and the values of ρ' for ordinates, and then from the curves drawn through the points so found he deduced various formulæ connecting v and ρ'.

93. My experiments with elongated shot, made in 1868, were subsequently reduced more carefully, after which process new coefficients were obtained, differing somewhat from those used by General Mayevski. Therefore Didion's ρ' has been calculated from the coefficients given in Tables II. and H. for both spherical and elongated shot for comparison with the results of other experimenters. Didion's $\rho' = \rho \div \pi R^2 v^2$, where ρ denotes the resistance of the air in kilogrammes to a shot of radius R moving with a velocity v, R and v being expressed in metres. Hence it appears from my experiments, both with spherical and ogival-headed projectiles, that ρ' is nearly constant for velocities above 1300 or 1400 *f.s*, or, in other words, for those and higher velocities the resistance of the air varies very nearly as the square of the velocity.

Spherical Shot.

Velocity		Hutton[1]	Didion[2]	Virlet[3]	Mayevski[4]	Bashforth[5]
f.s	*m.s*	ρ'	ρ'	ρ'	ρ'	ρ'
900	274·3	0·0521	0·0440	0·0389	0·0380	0·0373
1000	304·8	·0545	·0459	·0433	.0442	·0422
1100	335·3	·0569	·0478	·0476	·0510	·0499
1200	365·8	·0590	·0497	·0519	·0584	·0551
1300	396·2	·0609	·0516	·0563	·0610	·0575
1400	426·7	·0623	·0535	·0606	·0610	·0592
1500	457·2	·0634	·0554	·0649	·0610	·0602
1600	487·7	·0639	·0573	·0692	·0610	·0611
1700	518·2	·0640	·0592	·0736	·0610	·0615
1800	548·6	·0636	·0611	·0779	...	·0615
1900	579·1	·0628	·0630	·0822	...	·0618
2000	609·6	·0616	·0649	·0866	...	·0622
2100	640·1	...	·0668	·0909	...	·0623

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[1] Hutton's Experiments made with the Ballistic Pendulum at Woolwich, 1783—1791. *Tracts*, vol. III. p. 218.

[2] Didion's Experiments made with the Ballistic Pendulum at Metz, 1839, 1840. Didion's *Traité de Bal.* p. 66.

[3] Virlet's Experiments made with Navez E.B. Pendulum at Metz, 1856—1858. See Mayevski's *Traité de Bal.* p. 36.

[4] Mayevski's Experiments made with Boulengé's Chronograph at St. Petersburg, 1868, 1869. See *Traité de Bal.* p. 41.

[5] Bashforth's Experiments made with his Clock-Chronograph at Shoeburyness, 1868. See *Reports &c.*, p. 114.

Ogival-headed Shot.

Velocity f.s	m.s	Hélie[6] ρ′	Mayevski[7] ρ′	Bashforth[8] ρ′
100	30·5	...	0·0120	0·0174
200	61·0	...	0·0122	0·0174
400	121·9	...	0·0127	0·0177
600	182·9	...	0·0137	0·0180
800	243·8	0·0146	0·0150	0·0183
1000	304·8	0·0182	0·0224	0·0224
1200	365·8	...	0·0437	0·0393
1400	426·7	...	0·0437	0·0439
1600	487·7	...	0·0437	0·0430
1800	548·6	...	...	0·0416
2000	609·6	...	...	0·0412
2200	670·6	...	...	0·0441
2400	731·5	...	...	0·0428
2600	792·5	...	...	0·0408
2800	853·4	...	...	0·0436

94. It has been shewn (54) that

$$v_s = \frac{l}{\Delta t_s - \frac{1}{2}\Delta^2 t_s + \frac{1}{3}\Delta^3 t_s - \frac{1}{4}\Delta^4 t_s + \&c.},$$

and that $f_s = -\frac{v_s^3}{l^2}(\Delta^2 t_s - \Delta^3 t_s + \frac{11}{12}\Delta^4 t_s - \frac{10}{12}\Delta^5 t_s + \&c.)$.

If now we develope u_{s-nh} in the same manner as u_{s+nh} was developed, and equate coefficients of n and n^2, we obtain

$$v_s = \frac{l}{\Delta t_{s-l} + \frac{1}{2}\Delta^2 t_{s-2l} + \frac{1}{3}\Delta^3 t_{s-3l} + \frac{1}{4}\Delta^4 t_{s-4l} + \&c.}$$

and $f_s = -\frac{v_s^3}{l^2}(\Delta^2 t_{s-2l} + \Delta^3 t_{s-3l} + \frac{11}{12}\Delta^4 t_{s-4l} + \frac{10}{12}\Delta^5 t_{s-5l} + \&c.)$.

The formula (2) page 40 should have a term $\frac{1}{90}\Delta^6 t_{s-3l}$ instead of $\frac{12}{90}\Delta^6 t_{s-3l}$.

The expressions for the retarding force should have been written

$$f_5 = -\frac{v_5^3}{l^2}(\Delta^2 t_4 - \tfrac{1}{12}\Delta^4 t_3) \text{ at page 42,}$$

and $$f_3 = -\frac{v_3^3}{l^2}(\Delta^2 t_3 - \Delta^3 t_3) \text{ at page 44.}$$

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[6] Hélie's Experiments made at Gâvre 1859. Hélie's *Traité de Bal.* p. 416.

[7] Mayevski's Experiments made with Boulengé's Chronoscope at St. Petersburg, 1868–9. *Traité de Bal.* p. 41. § 27.

[8] Bashforth's Experiments made at Shoeburyness 1867–8 and 1878–80. See *Final Report.*

95. The example (57) given to illustrate the mode of reducing an experiment formed round 341 in the published *Reports*, *&c.*, 1865—1870. The above formulæ have been used to find v_1, v_2, v_3, &c., the velocities with which the projectile passed each of the ten screens; and also to find f_1, f_2, f_3, &c., the retarding forces which were acting upon it at the same points. This round was fired October 28, 1868. The barometer stood at 30·44 inches, and the wet and dry bulb thermometers at 44° and 48° at 10 o'clock A.M. These observations give 556·2 grs. as the weight of a cubic foot of air. And at 3 o'clock in the afternoon the barometer stood at 30·38 inches, and the wet and dry bulb thermometers at 48° and 50°, which observations give 551·5 grs. as the weight of a cubic foot of air. And the mean of these two is 553·9 grs. which has been taken as the weight of a cubic foot of air at the time of the experiment. All the experiments were originally reduced to the standard weight of 530·6 grs., which, for all *round shot*, remains unaltered, $l = 150$ feet.

$$v_7 = \frac{150}{\cdot 10417 - \frac{1}{2}\cdot 00367 + \frac{1}{3}\cdot 00011} = \frac{150}{\cdot 10237} = 1465\cdot 3\, f.s,$$

$$f_7 = -\frac{v_7^3}{(150)^2}(\cdot 00367 - \cdot 00011) = -v_7^3\frac{\cdot 00356}{(150)^2} = -2b'v_7^3.$$

$$\text{and}\quad K_7 = 2b'(1000)^3\frac{w}{d^2}\times\frac{530\cdot 6}{553\cdot 9}$$

$$= \frac{\cdot 00356}{(150)^2}\times(1000)^3\times\frac{44\cdot 094}{(6\cdot 92)^2}\times\frac{530\cdot 6}{553\cdot 9} = 139\cdot 6.$$

And in the same manner the rest may be found as stated in the following Table:

No. of Screen.	V $f.s$	ΔV	K_v	ΔK_v
1	1811·4	− 63·6	116·1	+ 3·9
2	1747·8	− 61·1	120·0	+ 3·9
3	1686·7	− 58·7	123·9	+ 3·9
4	1628·0	− 56·5	127·8	+ 3·9
5	1571·5	− 54·2	131·7	+ 3·9
6	1517·3	− 52·0	135·6	+ 4·0
7	1465·3	− 50·1	139·6	+ 4·3
8	1415·2	− 47·9	143·9	+ 4·3
9	1367·3	− 46·3	148·2	+ 4·3
10	1321·0		152·5	

From the above Table we easily find the values of K corresponding to velocities 1800, 1780, 1760...1340 *f.s.* The values of K for corresponding velocities have been also taken from Table II. for comparison.

v *f.s*	K_v Round 341	K_v Table II.	Error	v *f.s*	K_v Round 341	K_v Table II.	Error
1800	116·8	114·2	+ 2·6	1560	132·5	130·1	+ 2·4
1780	118·0	115·5	+ 2·5	1540	134·0	131·5	+ 2·5
1760	119·2	116·8	+ 2·4	1520	135.4	132·8	+ 2·6
1740	120·5	118·1	+ 2·4	1500	136·9	134·1	+ 2·8
1720	121·8	119·4	+ 2·4	1480	138·4	135·5	+ 2·9
1700	123·0	120·8	+ 2·2	1460	140·1	137·0	+ 3·1
1680	124·3	122·1	+ 2·2	1440	141·8	138·4	+ 3·4
1660	125·7	123·5	+ 2·2	1420	143·5	139·8	+ 3·7
1640	127·0	124·8	+ 2·2	1400	145·3	141·3	+ 4·0
1620	128·4	126·2	+ 2·2	1380	147·1	142·7	+ 4·4
1600	129·7	127·5	+ 2·2	1360	148·9	144.1	+ 4·8
1580	131·1	128·8	+ 2·3	1340	150·7	145·3	+ 5·4

On reference to the Report it will be found that the coefficients of resistance derived from the above round, and actually made use of, corresponded to velocities between 1700 and 1400 *f.s.* The reasons for making this limited use of each experiment were given as follows:—"A considerable "part of the extremities of the range in each round has been "rejected in finding the values of $2b'l^2$, because the records "of the first and last screens are not so trustworthy as those "of the intermediate screens, and at the two extremities of "the range the direction of the motion of the shot is not "so nearly horizontal as at the intermediate points," p. 59.

96. Still more remarkable was round 399, used as an example at page 57 of *Reports, &c.* In this case the round shot was hollow and weighed 7·894 lbs. Its diameter was 4·92 inches, and the density of the air on the day of the experiment was 1·0335. The values of the coefficients deduced from this round, and actually used, corresponded to velocities 2150 *f.s* to 1200 *f.s.* Values of K have been calculated from *this single round* corresponding to velocities between 2500 *f.s* and 1200 *f.s*, for comparison with the values of K given in Table II. for corresponding velocities.

V f.s	K_v Round 399	K_v Table II.	Error	V f.s	K_v Round 399	K_v Table II.	Error
2500	82·5	...	...	1750	117·8	117·4	+ 0·4
2400	86·6	...	...	1700	120·6	120·8	− 0·2
2300	90·8	...	...	1650	123.7	124·1	− 0·4
2200	95·2	...	...	1600	126·8	127·5	− 0·7
2150	97·5	96·9	+ 0·6	1550	129·9	130·8	− 0·9
2100	99·8	99·2	+ 0·6	1500	133·1	134·1	− 1·0
2050	102·2	101·5	+ 0·7	1450	136·4	137·7	− 1·3
2000	104·6	103·9	+ 0·7	1400	139·8	141·3	− 1·5
1950	107·1	106·3	+ 0·8	1350	143·4	144·7	− 1·3
1900	109·7	108·7	+ 1·0	1300	147·3	147·8	− 0·5
1850	112·4	111·3	+ 1·1	1250	151·3	151·1	+ 0·2
1800	115·1	114·2	+ 0·9	1200	155·5	153·4	+ 2·1

97. As a further illustration of the power of this chronograph I give below the values of K for flat-headed and hemispherical-headed elongated shot derived from *three* rounds of each form of head for comparison with the value of K for ogival-headed shot.*

V f.s	Ogival Head	Hemi-spherical Head	Flat Head	V f.s	Ogival Head	Hemi-spherical Head	Flat Head
1520	96·2	...	173·3	1700	83·0	113·6	173·5
1530	95·3	...	173·6	1710	82·4	113·1	173·2
1540	94·4	...	173·8	1720	81·8	112·6	172·9
1550	93·6	...	173·9	1730	81·2	112·0	172·5
1560	92·8	...	174·0	1740	80·6	111·4	172·1
1570	92·0	...	174·1	1750	80·0	110·8	171·7
1580	91·2	...	174·2	1760	79·5	110·2	171·2
1590	90·4	...	174·3	1770	78·9	109·5	170·7
1600	89·7	...	174·4	1780	78·4	108·8	170·2
1610	89·0	...	174·5	1790	77·8	108·0	169·7
1620	88·3	...	174·5	1800	77·3	107·1	169·1
1630	87·6	...	174·5	1810	76·8	106·1	168·6
1640	86·9	115·8	174·5	1820	76·2	105·1	168·0
1650	86·2	115·5	174·4	1830	75·7	104·0	167·4
1660	85·5	115·2	174·3	1840	75·2	102·9	166·8
1670	84·8	114·8	174·2	1850	74·7	101·7	166·2
1680	84·2	114·4	174·0	1860	74·2	100·5	165·6
1690	83·6	114·0	173·8	1870	73·6	99·3	165·0

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* See *Final Report*, pp. 37, 40, and 43.

98. If now we increase the values of K_v given in Table II. by 2-300ths of their values to render the supposed density of the air there the same as in the above table, we shall find that the value of K_v for a hemispherical-headed elongated shot is a little smaller than that for round shot. Thus, for velocities 1650 *f.s* 1700 *f.s* 1750 *f.s* 1800 *f.s* and 1850 *f.s*

K_v for ½-spherical heads is	115·5	113·6	110·8	107·1	101·7
K_v for spherical shot is	124·9	121·6	118·2	115·0	112·1
Difference	9·4	8·0	7·4	7·9	10·4

The value of K_v for hemispherical-headed shot was found to be 133·1 for a mean velocity of about 1130 *f.s*,[*] while that for spherical shot for the same velocity was 153·1, as given in Table II.

99. It is remarkable through what a wide range of velocities a very correct *law* of resistance to spherical shot is given by each of the rounds 341 and 399. But the like favourable result cannot be expected from any single round of ogival-headed elongated shot. For the resistance of the air to a pointed elongated shot is less than the resistance to a spherical shot of the same diameter, while the former is heavier than the latter. On both accounts the variation of velocity of an elongated ogival-headed shot, in a given range, will be much less than that of a spherical shot under like conditions. If the round shot be truly spherical, it will always present the same surface to be resisted, while this is perhaps seldom the case with an elongated shot through any considerable range.

With high velocities the shot moves in an approximately straight line, it cuts the threads of the screens promptly, and the retarding force of the air, being great, causes great variation in the velocity of the shot. So there is no difficulty in finding the resistance of the air to projectiles moving at *high* velocities. But when we get below a velocity of about 1000 *f.s* our difficulties go on increasing as the velocities decrease. The trajectory becomes so curved that we are limited in range, or have to leave out the central screens. An ogival-headed projectile, 3 inches in diameter will then often pass between the threads of the screens, only one inch apart, without breaking one of them, and the resistance of the air is so reduced that it produces only a slight variation of the velocity of the shot in a single round.

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[*] *Reports, &c.*, p. 13, and *Phil. Trans.* p. 426, 1868.

100. After the coefficients of resistance had been found in the usual manner down to a velocity of 450 *f.s*, the trajectories and times of flight were carefully calculated for the 6·3-inch howitzer, and compared with the range tables given in the *Instructions for Field Service*, 1879, and also with numerous German range tables, where the value of $d^2 \div w$ was nearly the same as for the English howitzer.* As these comparisons appeared to be as satisfactory as could be reasonably expected, the coefficients were plotted, making v the abscissa and K_v the ordinate. The average curve passing among the points so determined was produced so as to give approximate values of K for still lower velocities. Special experiments were afterwards made with the 6·3-inch howitzer with low charges of $1\frac{1}{2}$ lb., 1 lb., $\frac{3}{4}$ lb., $\frac{1}{2}$ lb. and $\frac{1}{4}$ lb. in order to test the value of these coefficients, when employed to calculate the ranges and times of flight of projectiles moving with *very low* velocities. The result appeared to be satisfactory.†

101. In these comparisons of the results of calculation and experiment great discrepancies appeared in the cases of "final velocities" and "angles of descent." This shews how much the final velocities and the angles of descent of ordinary range tables need correction, for it is manifest that these are not matters which admit of accurate measurement. But if a set of coefficients give tolerably correct ranges and times of flight for various low muzzle velocities and various elevations, there can be no doubt about the accuracy of the terminal velocities and angles of descent calculated by the help of those coefficients.

It is probable that the coefficients adopted for low velocities are somewhat greater than those which would have been obtained if the projectiles had moved with their axes strictly in the direction of motion during the experiments. Still, so far as they have been derived from experiment, they are such as may be expected in practice, for at low velocities projectiles must move with their axes inclined to the direction of motion, because their trajectories are much curved. In the experiments made with low charges care was taken to measure the "jump" for elevations up to 30°, but these were found to be so small and irregular that they could be neglected.‡

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* See *Final Report*, 1880, Tables XII. (A) and (B), pages 45–47.

† *Final Report*, p. 7, and Table XIII., p. 49.

‡ *Final Report*, p. 6.

102. I have not had an opportunity of testing the value of the coefficients of resistance for high velocities by a comparison of calculated and experimental ranges and times of flight. And there does not appear to be much necessity for this, as the experiments with high velocities are so satisfactory. It is probable that the projectiles in these experiments moved with their axes more nearly in the direction of their motion than would be the case throughout a long range. That would lead us to expect the calculated range to be too great. With high charges the "jump" of the gun might be expected to give too great an experimental range. And if the elevation of the gun was considerable, a great part of the horizontal motion of the shot would take place in air much less dense than that for which the coefficients hold good. This would cause the experimental ranges to exceed the calculated ranges. But in these cases the "jump" may be measured by careful experiment, and in calculating the trajectory, account may be taken of the decreasing density of the air as the projectile rises above the earth.

103. The new values of K for ogival-headed elongated shot, given in Table H., have been calculated on the supposition that the weight of a cubic foot of air is 534·22 grs., which is the weight of a cubic foot of dry air at a temperature 62°F., under a pressure of 30 inches of mercury. The values, therefore, of K in Tables I. and C. have been increased in the ratio 530·6 : 534·22, or the old values of K have received an increment of about 2-300ths of their former values. But as no new experiments have been made with *round* shot, the values of K in Table II. remain unchanged.

When calculating a trajectory, &c. suppose that a cubic foot of air weighs $(534{\cdot}22 \pm \Delta)$ grs., this may be allowed for in the following manner. K_v is generally found multiplied by $\frac{d^2}{w}$. In this case $\frac{d^2}{w} K_v$ becomes

$$\frac{d^2}{w} \times \left\{ \left(1 \pm \frac{\Delta}{534{\cdot}22}\right) K_n \right\} = \left\{ \frac{d^2}{w} \left(1 \pm \frac{\Delta}{534{\cdot}22}\right) \right\} \times K_v.$$

When then $\frac{d^2}{w}\left(1 \pm \frac{\Delta}{534{\cdot}22}\right)$ is once found, it can be used in the calculations in combination with the tabular values of K_v. This will be found a simpler process than correcting the tabular values of K_v, for in the case of the General Tables, we shall have

$$\frac{d^2}{w}\left(1 \pm \frac{\Delta}{534{\cdot}22}\right) \times t = T_V - T_v,$$

and $$\frac{d^2}{w}\left(1 \pm \frac{\Delta}{534{\cdot}22}\right) \times s = S_V - S_v\,;$$

or, if we suppose the normal height of the barometer to be 30 inches, and the observed height $30 \pm \beta$ inches, then we shall have

$$\frac{d^2}{w}\left(1 \pm \frac{\beta}{30}\right) t = T_V - T_v,$$

and $$\frac{d^2}{w}\left(1 \pm \frac{\beta}{30}\right) s = S_V - S_v.$$

104. In the careful calculation of the trajectory of a shot, it will be necessary to take into account the diminution in the density of the air corresponding to the probable height above the surface of the earth of the middle of each successive arc into which the trajectory is divided.

The following Table calculated for a temperature of 62° will be useful in taking account of this diminution of the density of the air as the shot rises. The height of the shot is expressed in feet, and the height of the barometer in inches. Thus, suppose that the height of the barometer at the surface of the ground is 29 inches. This corresponds to a height 2700 feet in the Table. When the shot is 2200 feet above the ground, the height of the barometer corresponding to $2700 + 2200 = 4900$ feet is 26·84 inches. And the proper value of K will here be $K \times 26{\cdot}84 \div 30$, approximately.

H.	0	100	200	300	400	500	600	700	800	900	Mean Diff.
Ft.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	
0	32·00	31·89	31·78	31·66	31·55	31·44	31·33	31·22	31·11	31·00	·111
1000	30·88	30·77	30·65	30·54	30·43	30·32	30·21	30·10	30·00	29·89	·110
2000	29·78	29·67	29·57	29·46	29·35	29·25	29·14	29·04	28·93	28·83	·106
3000	28·73	28·62	28·52	28·42	28·32	28·22	28·12	28·02	27·92	27·81	·102
4000	27·71	27·61	27·52	27·42	27·32	27·22	27·13	27·03	26·93	26·84	·097
5000	26·74	26·65	26·55	26·46	26·36	26·27	26·17	26·08	25·98	25·89	·094
6000	25·79	25·70	25·61	25·51	25·42	25·33	25·24	25·15	25·06	24·97	·091
7000	24·88	24·79	24·70	24·61	24·53	24·44	24·35	24·26	24·18	24·09	·088
8000	24·00	23·92	23·83	23·75	23·66	23·58	23·49	23·41	23·32	23·24	·085
9000	23·16	23·07	22·99	22·91	22·83	22·74	22·66	22·58	22·50	22·42	·082
10000	22·34	22·26	22·18	22·10	22·02	21·94	21·86	21·78	21·70	21·63	·079
11000	21·55	21·48	21·40	21·33	21·25	21·17	21·09	21·02	20·94	20·87	·076
12000	20·79	20·72	20·64	20·57	20·49	20·42	20·35	20·27	20·20	20·13	·073
13000	20·06	19·98	19·91	19·84	19·77	19·70	19·63	19·56	19·49	19·42	·071
14000	19·35	19·28	19·21	19·14	19·07	19·00	18·94	18·87	18·80	18·73	·069
15000	18·67	18·60	18·53	18·47	18·40	18·34	18·27	18·21	18·14	18·08	·066

105. In the groups of values of K_v for low velocities (see Final Report) there is often a greater variation in these values than might have been expected, and in consequence of the shot having so frequently passed through the screens without giving a record, it is difficult to decide whether these irregularities be entirely due to the unsteadiness of the shot. All that I could do was to reduce the records sent to me as carefully as possible and state the result. It must be borne in mind also that the unit in the value of K_v depends upon the second differences of the times of passing each screen expressed to the 1-100000th of a second. It is not pretended that any chronograph can measure time practically to this fabulous nicety, but in reducing the observations, where the records were read off to the 1-3000th of a second, it was found insufficient for the purposes of calculation to express time in seconds to four places of decimals only, and consequently five places are always used now. The experiments were nearly completed before either of the two following plans suggested themselves as likely to secure a good record for every screen passed through by the shot.

106. First, drill three or more equidistant holes normally to the surface of the head of the shot, not far from the cylindrical part, and plug these holes with soft wood. Just before loading fix pieces of softened watch spring wire in each of these plugs, sharpened on the front edge, so that they may clear the gun and yet catch the string of the screens. I have tried a wooden model dropped from the height of 3 or 4 feet on strong threads stretched horizontally with perfect success.

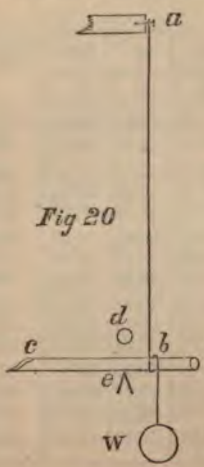

Fig 20

The second method depends on an alteration of the screen. A strong linen thread is to be attached to a *fixed* point *a* (fig. 20) at the top of the screen, and carry a sufficient weight *W* attached at the other end. The arrangement for breaking circuit by wire springs *cb* is much the same as that which has been used hitherto, only the springs act downwards here. Each string of the screen is turned once about the round spring wire at *b*, so that the weight *W* will keep the string *ab* stretched, and when a *sudden* pressure comes against the thread *ab*, the spring *cb* will be jerked upwards sufficiently to break contact at *e*; *d* is a stop.

107. Robins and Hutton endeavoured to determine the resistance of the air to the motion of bodies of various forms for very low velocities by the use of the whirling machine. When the motion of the machine appeared to be uniform they found the average time of a revolution, and thence deduced the resistance of the air. My chronograph is well adapted for experiments of this kind, because it would give the exact time of each successive revolution, beginning from rest, and so afford means for calculating the retarding force for all velocities below the greatest attained. Yet there is not much encouragement to pursue this method of experimenting as it has only been used for velocities below 25 *f.s*, and there seems to be a liability to error arising from friction and from the stretching and rigidity of the string. It therefore appears that it would be preferable to experiment with bodies of the required forms, constructed of some suitable light material, falling freely under the action of gravity. The arrangement shewn at fig. 11 would be very suitable for dropping the bodies. If the greatest available height were H, then I would first find the time of falling from rest through a height $\frac{1}{10}H$, taking the mean of 8 or 10 experiments. Afterwards I would find the time of falling freely through heights of $\frac{2}{10}H$, $\frac{3}{10}H$, &c. When the experiment was completed these times might be differenced, and hence the retarding force of the air might be deduced as in (55) and (57).

108. When γ is large, $1-\gamma(3p+p^3)$ varies rapidly, and therefore it is not convenient to calculate the values of X, Y and T in such cases by quadratures in the usual manner from formulæ (6), (7) and (8) in (63).

In (62) we have found

$$\begin{aligned}\frac{1}{u^3} &= \frac{1}{u_0^3} - \frac{2b}{g}(3p+p^3)\\ &= \frac{1}{u_0^3}\{1-\gamma(3p+p^3)\}.\end{aligned}$$

When $\phi=\phi_1$, or $p=p_1$, suppose $u=\infty$, and then we have

$$3p_1+p_1^3=\frac{1}{\gamma}=\frac{g}{2bu_0^3};$$

therefore

$$\left(-\frac{1}{g}\frac{dp}{dt}\right)^3=\frac{1}{u^3}=\frac{\gamma}{u_0^3}\left\{\frac{1}{\gamma}-(3p+p^3)\right\}=\frac{2b}{g}\{(3p_1+p_1^3)-(3p+p^3)\},$$

or
$$\frac{dt}{dp} = -\frac{1}{(2bg^2)^{\frac{1}{3}}} \times \frac{1}{\{(3p_1 + p_1^3) - (3p + p^3)\}^{\frac{1}{3}}},$$

therefore

$$t = -\frac{1}{(2bg^2)^{\frac{1}{3}}} {}^{\phi}\!\!\int^{\phi'} \frac{(1+p^2)\,d\phi}{\{(3p_1 + p_1^3) - (3p + p^3)\}^{\frac{1}{3}}} = -\frac{1}{(2bg^2)^{\frac{1}{3}}} {}^{\phi}T'^{\phi'},$$

and, similarly,

$$x = -\frac{1}{(4b^2g)^{\frac{1}{3}}} {}^{\phi}\!\!\int^{\phi'} \frac{(1+p^2)\,d\phi}{\{(3p_1 + p_1^3) - (3p + p^3)\}^{\frac{2}{3}}} = -\frac{1}{(4b^2g)^{\frac{1}{3}}} {}^{\phi}X'^{\phi'},$$

and

$$y = -\frac{1}{(4b^2g)^{\frac{1}{3}}} {}^{\phi}\!\!\int^{\phi'} \frac{p(1+p^2)\,d\phi}{\{(3p_1 + p_1^3) - (3p + p^3)\}^{\frac{2}{3}}} = -\frac{1}{(4b^2g)^{\frac{1}{3}}} {}^{\phi}Y'^{\phi'}.$$

The above formulæ have been used in calculating tables of values of X', Y' and T', for $3p_1 + p_1^3$ equal to 0·01, 0·001, 0·0001 and 0, or for values of $\gamma = 100$, 1000, 10000 and infinity.

109. Let P_1PAB (fig. 21) be the trajectory of a given shot, on the supposition that the resistance of the air varies as the cube of the velocity. If now the given shot be projected from any point P in the direction of the tangent Pt at

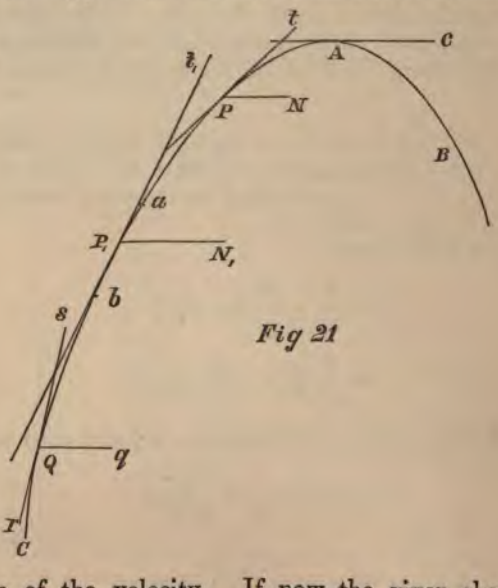

Fig 21

that point, which is inclined to the horizontal line PN at an angle ϕ, with the velocity v_ϕ, it will describe the path PAB, if v_ϕ be determined from the equation

$$\left(\frac{1}{v_\phi \cos\phi}\right)^3 = \frac{1}{u_0^3}\{1 - \gamma(3\tan\phi + \tan^3\phi)\}.$$

As the point of projection approaches P_1, ϕ will increase and $1-\gamma(3\tan\phi+\tan^3\phi)$ will decrease, and, therefore, v_ϕ will increase. At P_1, when $\phi=\phi_1$, suppose that

$$1-\gamma(3\tan\phi_1+\tan^3\phi_1)=0, \text{ then } v_{\phi_1}=\infty.$$

If we suppose ψ to be larger than ϕ_1, $1-\gamma(3\tan\psi+\tan^3\psi)$ is negative, and, therefore, v_ψ is negative. That is, if $sQq=\psi$, then the shot must be projected from Q *downwards* in the direction Qr.

110. Thus the velocity of projection *upwards* decreases from ∞ at P_1 to u_0 at the vertex A. And the velocity of projection *downwards* decreases from ∞ at P_1 towards C, till it becomes a minimum at a point where the resolved part of gravity in the direction of the tangent is equal to the retarding force of the air, or where $g\sin\psi=2bv_\psi^3$. And substituting for v_ψ its value from

$$(v_\psi\cos\psi)^{-3}=u_0^{-3}\{\gamma(3\tan\psi+\tan^3\psi)-1\},$$

we arrive at the equation, $\tan 2\psi=-2\gamma$ for determining ψ.

111. P_1AB and P_1QC are independent branches, having a common tangent at P_1. If we supposed the shot to move under the action of gravity and an *accelerating* force $2bv^3$ in the arc CQP_1, and that the force $+2bv^3$ suddenly changed to $-2bv^3$ at P_1 when the velocity was infinite, then a single shot could be made to describe the whole arc CP_1AB continuously.

112. The velocity of the shot moving in the neighbourhood of P_1 is very great, so that arcs P_1a and P_1b are not important because we do not possess any practical means of communicating the corresponding high velocities to the shot. Tables of values of X, Y and T have been calculated for all practically useful values of ϕ between $+60°$ and $-60°$, from $\gamma=0$ to $\gamma=1{\cdot}0$; and after that for values of ϕ down to $-45°$, from $\gamma=1{\cdot}1$ to $\gamma=\infty$, where $1-\gamma(3\tan\phi+\tan^3\phi)$ is positive. These tables, therefore, apply to the branch aAB only. If it was desired to depress guns very much it would

be necessary to calculate tables where $\gamma(3\tan\psi+\tan^3\psi)-1$ is positive, which would apply to the branch bQC.

113. We can find the extreme depression of each gun for which the accompanying tables enable us to calculate the trajectory. When a shot is fired from a gun *elevated* above the horizon it is known that it will pass the vertex of the trajectory with a velocity u_0, *less* than the velocity of projection. But when a gun is *depressed* below the horizon, the theoretical velocity u_0 at the vertex A of the trajectory will generally be greater than the velocity of projection. If the velocity of the shot would pass through infinity between the vertex A and the point of projection B, then the tables already calculated do not apply to the case. But if the velocity would be infinite at the vertex A, or on the side AP_1, then the accompanying tables are applicable. Let the shot be fired at an angle ϕ' below the horizon with an initial velocity v. Then we have

$$\left(\frac{1000}{u_0}\right)^3=\left(\frac{1000}{v\cos\phi'}\right)^3-\frac{K}{g}\frac{d^2}{w}P_{\phi'}.$$

Suppose now, that $u_0=\infty$ and that $v\cos\phi'=1500 f.s$, then we obtain,

$$P_{\phi'}=\left(\frac{1000}{1500}\right)^3\div\left(\frac{K}{g}\frac{d^2}{w}\right),$$

from which ϕ' can be found by the help of Table V. or D. after numerical values have been assigned to K, d and w.

Example 1. Take the 11·6-inch gun, where $d=11{\cdot}52$ inches, $w=700$ lbs., and therefore $d^2\div w=0{\cdot}1896$, and $K\div g=3{\cdot}134$.

$$P_{\phi'}=\left(\frac{1000}{1500}\right)^3\div(3{\cdot}134\times0{\cdot}1896)={\cdot}49865,$$

which gives $\phi'=9^\circ 20'$ nearly.

Hence the tables already calculated apply to all elevations of this gun from $+60^\circ$ to $-9^\circ 20'$.

Example 2. Take the 3-inch gun, where $d=2{\cdot}92$ inches, $w=12$ lbs., and therefore $d^2\div w=0{\cdot}7105$.

$$\text{Here}\quad P_{\phi'}=\left(\frac{1000}{1500}\right)^2\div(3{\cdot}134\times0{\cdot}7105)=0{\cdot}13306,$$

which gives $\phi'=2^\circ 32'$.

Hence the accompanying Tables apply to all elevations of the 3-inch gun from $+60^\circ$ to $-2^\circ 32'$.

114. Let v_α, v_β be the velocities of a shot moving in the ascending branch of its trajectory at points where the tangents are inclined to the horizon at angles α, β respectively, and $K \div g$ the mean coefficient through the intervening arc $(\alpha - \beta)$. Suppose that v_α is given, then in order to find v_β we must make use of the equation

$$\left(\frac{1000}{u_\beta}\right)^3 = \left(\frac{1000}{u_\alpha}\right)^3 + \frac{K}{g}\,\frac{d^2}{w}\,(P_\alpha - P_\beta) \ldots (A).$$

But we cannot assign a correct value to $K \div g$ till we have found u_β. On referring to Table I. or H. giving corresponding values of v and $K \div g$, it will be found that sometimes $K \div g$ is varying *slowly* with v, while at other times it is constant or nearly so. It will, therefore, be advisable to begin by assuming a value for $K \div g$ equal to that given in the table opposite to v_α, or, preferably, to a velocity something less. Substitute this value of $K \div g$ in the above equation, and then v_β a good *first* approximation to v_β will generally be found, if the arc $(\alpha - \beta)$ be not too large.

Now find the mean value of $K \div g$ between v_α and v_β. If the first adopted value of $K \div g$ require a small *positive* correction then v_β will require a small *negative* correction. The way in which this correction may be introduced will be best seen from an example.

Taking the example worked out at p. 60, we have given $v_\alpha = v_5 = 1335 \, f.s$; $u_5 = 1329{\cdot}9 \, f.s$; $d^2 \div w = {\cdot}56935$. And on referring to Table I. we find for a velocity $1335 \, f.s$ the value $3{\cdot}322$ for $K \div g$. Substituting in the above equation, we have

$$\left(\frac{1000}{\mathrm{u}_4}\right)^3 = \left(\frac{1000}{1329{\cdot}9}\right)^3 + 3{\cdot}322 \times 0{\cdot}56935 \times 0{\cdot}05301$$

$$= 0{\cdot}42515 + 0{\cdot}10026 = 0{\cdot}52541,$$

which gives $\mathrm{u}_4 = 1239{\cdot}3 \, f.s$;

and $\mathrm{v}_4 = 1239{\cdot}3 \sec 4^\circ = 1242{\cdot}3 \, f.s.$

The value of $K \div g$ corresponding to the mean of the velocities $1335 \, f.s$ and $1242{\cdot}3$ will be found by Table I. to be $3{\cdot}358 = 3{\cdot}322 + {\cdot}036 = K \div g + \delta K \div g$. Now

$$K \div g = 3{\cdot}322 \qquad \text{gave } {\cdot}10026,$$

therefore $+\delta K \div g = 0{\cdot}036$ will give $+{\cdot}00109$,

and from Table F. it appears that for a velocity about $1239 \, f.s$ a correction of $+{\cdot}00127$ applied to $(1000 \div v)^3$ gives a correction $-1{\cdot}0$ *f.s* to be applied to v. Therefore, a correction $+{\cdot}00109$ will give a correction of $-0{\cdot}9$ *f.s* to the velocity, or

$$u_\beta = u_4 = 1239{\cdot}3 - 0{\cdot}9 = 1238{\cdot}4 \text{ f.s.}$$

115. If we proceed to calculate *first* approximate values of u_3, u_2, u_1 and u_0, using the same value 3·322 of $K \div g$, we find

$u_3 = 1169{\cdot}5$ *f.s* instead of 1167·8,
$u_2 = 1113{\cdot}3$..................1111·6,
$u_1 = 1066{\cdot}8$..................1066·0,
and $u_0 = 1027{\cdot}1$..................1031·9.

Thus it appears that a somewhat erroneous value of $K \div g$ will generally give a very fair *first* approximation to v_β. And this arises from the fact that when the arc $(\alpha - \beta)$ is properly assigned, $K \div g$ is always multiplied by a very small quantity. For $d^2 \div w$ varies from about 3 for a small arm bullet to 0·25 for the 10-inch gun, and becomes still less for larger guns. When $d^2 \div w$ is large $\alpha - \beta$ must be small, say about 0°·5, then $d^2 \div w \times (P_\alpha - P_\beta) = 3 \times 0{\cdot}03 = 0{\cdot}09$ nearly. In calculating trajectories for the 6·3-inch howitzer for low velocities (below 800 *f.s*), where $d^2 \div w = 0{\cdot}5616$, it was found very satisfactory to divide the trajectory into arcs of 4° or 5°.

116. Some difficulty has been experienced in calculating v_β from the equation (A) where K generally varies slowly with v. The trajectory has to be broken up into a series of small arcs through each of which K has to be supposed constant, and equal to the mean value between v_α and v_β. If the arc $(\alpha - \beta)$ be properly chosen K may have its mean value derived from the table of values of $\Sigma\,(K \div g)$, or it may be the mean of its values corresponding to v_α and v_β, or it may be the value of K corresponding to the mean velocity $\frac{1}{2}(v_\alpha + v_\beta)$. For if the results differed sensibly it would appear that the arc $(\alpha - \beta)$ was too large. As the problem does not admit of a direct and precise solution it is necessary to resort to approximations. But if these approximations be intelligently carried out, any required degree of precision may easily be obtained in the result; and the smaller the arcs are taken the more nearly exact becomes the result.

117. But to meet this difficulty I have calculated an auxiliary Table J., where

$$R_v = \Sigma_{100}^{v} \left[\left\{ \left(\frac{1000}{v-1}\right)^3 - \left(\frac{1000}{v}\right) \right\} \frac{g}{K_{v-\frac{1}{2}}} \right].$$

By this we find

$$R_{v_\alpha} - R_{v_\beta} = \left\{ \left(\frac{1000}{v_\beta} \right)^3 - \left(\frac{1000}{v_\alpha} \right)^3 \right\} \frac{g}{K},$$

where K is supposed to vary continuously with v, from v_α to v_β. But in the equation we have to deal with, v_α and v_β are replaced by u_α and u_β. We must, therefore, put the equation (A) under the form

$$\left\{ \left(\frac{1000}{v_\beta \cos\beta \sec\alpha} \right)^3 - \left(\frac{1000}{v_\alpha} \right)^3 \right\} \frac{g}{K} = \frac{d^2}{w} (P_\alpha - P_\beta) \cos^3\alpha,$$

where $$R_{v_\alpha} - R_{v_\beta \cos\beta \sec\alpha} = \frac{d^2}{w} (P_\alpha - P_\beta) \cos^3\alpha \text{ ......(I)},$$

for the ascending branch, or

$$\left(\frac{1000}{v'_\beta} \right)^3 - \left(\frac{1000}{v'_\alpha \cos\alpha \sec\beta} \right)^3 = \frac{d^2}{w} (P_\beta - P_\alpha) \cos^3\beta,$$

or $$+ R_{v'_\alpha \cos\alpha \sec\beta} - R_{v'_\beta} = \frac{d^2}{w} (P_\beta - P_\alpha) \cos^3\beta \text{ (II)},$$

for the descending branch, where, the smaller $\cos\alpha \sec\beta$ is, the nearer the calculated result will approach the true result.

118. Suppose that a Martini-Henry bullet is projected at an elevation of 1° above the horizon, with a velocity of 1353 *f.s.* Then $d = 0\cdot45$ inch; $w = 480$ grs. $= 0\cdot06857$ lbs.; and $d^2 \div w = 2\cdot953$. As the velocity of the bullet will vary rapidly in consequence of the high value of $d^2 \div w$, it will be advisable to employ the general Table J. to calculate the velocities when the bullet is moving in directions inclined at $0^\circ\cdot5$, 0, $-0^\circ\cdot5$, $-1^\circ\cdot0$ and $-1^\circ\cdot3$ to the horizon. We thus obtain

$$v_{0\cdot5} = 1145\cdot3 \, f.s; \; u_0 = 1034\cdot7 \, f.s; \; v'_{0\cdot5} = 973\cdot6 \, f.s;$$
$$v'_{1\cdot0} = 924\cdot9 \, f.s; \; v'_{1.3} = 900\cdot0 \, f.s.$$

And using the tabular values of X, Y and T, we find:

$$\begin{array}{lll} {}_1x_{0\cdot5} = 416\cdot8 \text{ feet}; & {}_1y_{0\cdot5} = 5\cdot553 \text{ feet}; & {}_1t_{0\cdot5} = 0''\cdot3357 \\ {}_{0\cdot5}x_0 = \underline{321\cdot0} \;\; ,, & {}_{0\cdot5}y_0 = \underline{1\cdot463} \;\; ,, & {}_{0\cdot5}t_0 = \underline{0\;\cdot2948} \\ {}_1x_0 = \underline{737\cdot8} \;\; ,, & {}_1y_0 = +\underline{7\cdot016} \;\; ,, & {}_1t_0 = \underline{0\;\cdot6305} \end{array}$$

and for the descending branch:

$$
\begin{array}{rlrlr}
{}_{0}x_{0\cdot5}=272\cdot7 & \text{feet;} & {}_{0}y_{0\cdot5}=1\cdot164 & \text{feet;} & {}_{0}t_{0\cdot5}=0''\cdot2723\\
{}_{0\cdot5}x_{1\cdot0}=244\cdot3 & ,, & {}_{0\cdot5}y_{1}=3\cdot191 & ,, & {}_{0\cdot5}t_{1\cdot0}=0\ \cdot2571\\
{}_{1\cdot0}x_{1\cdot3}=135\cdot3 & ,, & {}_{1}y_{1\cdot3}=2\cdot726 & ,, & {}_{1\cdot0}t_{1\cdot3}=0\ \cdot1488\\
\hline
{}_{0}x_{1\cdot3}=+652\cdot3 & ,, & {}_{0}y_{1\cdot3}=-7\cdot081 & ,, & {}_{0}t_{1\cdot3}=+0\ \cdot6782\\
{}_{1}x_{0}=+737\cdot8 & ,, & {}_{1}y_{0}=+7\cdot016 & ,, & {}_{1}t_{0}=+0\ \cdot6305\\
\hline
1390\cdot1 & ,, & -0\cdot065 & ,, & 1\cdot\ 3087\\
\hline
\end{array}
$$

A correction of $-0\cdot065$ applied to y will give a correction $-0\cdot065\cot 1^\circ\cdot3=-2\cdot9$ ft. to be applied to x, and a correction $-2\cdot9\div900\times1''=-0''\cdot0032$ to t. Hence the range on the horizontal plane passing through the point of projection is $1390\cdot1-2\cdot9$ feet $=1387\cdot2$ feet. The greatest height to which the bullet rises above this plane is $7\cdot016$ feet. And the time of flight is $1''\cdot3087-0''\cdot0032=1''\cdot3055$.

Or, if we divide the trajectory into two parts at the vertex we obtain $u_0=1034\cdot5\,f.s$; $v'_{1\cdot3}=900\cdot0\,f.s$; and

$$
\begin{array}{rlrlr}
{}_{1}x_{0}=747\cdot0 & \text{feet;} & {}_{1}y_{0}=+7\cdot114 & \text{feet; and} & {}_{1}t_{0}=0''\cdot6344\\
{}_{0}x_{1\cdot3}=652\cdot3 & ,, & {}_{0}y_{1\cdot3}=-7\cdot080 & ,, & {}_{0}t_{1\cdot3}=0\ \cdot6781\\
\hline
1399\cdot3 & & +0\cdot034 & & 1\ \cdot3125\\
\hline
\end{array}
$$

Hence the range on the horizontal plane is $1399\cdot3+1\cdot5=1400\cdot8$ feet. The greatest height is $7\cdot114$ feet, and the time of flight is $1''\cdot3125+0''\cdot0016=1''\cdot3141$.

119. When, as in the above example, a shot is moving in a direction so little inclined to the horizon that the resolved part of gravity in the direction of its motion is very small, the general Tables L. and M. may be used to calculate the trajectory in the following manner. Suppose α, β, to be the inclination to the horizon of the tangents to the trajectory at the points O, P. Then the velocity of the shot v_a at O being supposed to be known, its velocity v_β at P can be found by the help of the Table J. And by the help of

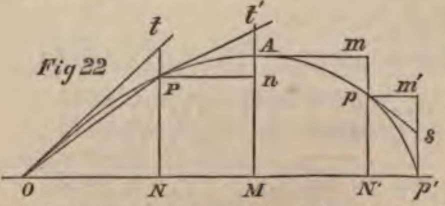
Fig 22

the general Tables L. and M. it can be found in what space s and in what time t, the velocity of the shot, unaffected by gravity, will be reduced from v_a to v_β. Then take the angle $NOt = \alpha$; $Ot = s$; and draw tN perpendicular to the horizontal line passing through O. Then

$$ {}_{a}x_{\beta} = ON = Ot \cos\alpha = s\cos\alpha\,; $$

and $$ y = PN = Nt - tP = s\sin\alpha - \tfrac{1}{2}gt^2. $$

The value of $\frac{1}{2}gt^2$ will be found from Table G. when t is known. In the descending branch we have

$$ pN' = m'p' = m's + sp' = ps\sin spm' + \tfrac{1}{2}gt'^2. $$

In the above example we find

$$ \begin{aligned} &{}_{1}s_{0\cdot5} = 416{\cdot}5 \text{ feet};\ {}_{0\cdot5}s_{0} = 318{\cdot}8 \text{ feet};\ {}_{0}s_{0\cdot5} = 272{\cdot}9 \text{ feet};\\ &{}_{0\cdot5}s_{1} = 244{\cdot}2\ \ \text{,,}\ ;\ {}_{1}s_{1\cdot3} = 135{\cdot}1\ \ \text{,,}\ ;\\ \text{and}\ &{}_{1}t_{0\cdot5} = 0''{\cdot}3359;\ {}_{0\cdot5}t_{0} = 0''{\cdot}2940;\ {}_{0}t_{0\cdot5} = 0''{\cdot}2722;\\ &{}_{0\cdot5}t_{1} = 0''{\cdot}2579;\ {}_{1}t_{1\cdot3} = 0''{\cdot}1483. \end{aligned} $$

$$ \begin{array}{lll} {}_{1}x_{0\cdot5} = 416{\cdot}4 \text{ feet}; & {}_{1}y_{0\cdot5} = 5{\cdot}452 \text{ feet}; & {}_{1}t_{0\cdot5} = 0''{\cdot}3359 \\ {}_{0\cdot5}x_{0} = 318{\cdot}7\ \ \text{,,}\ ; & {}_{0\cdot5}y_{0} = 1{\cdot}391\ \ \text{,,}\ ; & {}_{0\cdot5}t_{0} = 0\ {\cdot}2940 \\ \hline {}_{1}x_{0} = 735{\cdot}1 & {}_{1}y_{0} = 6{\cdot}843 & {}_{1}t_{0} = 0{\cdot}6299 \\ \hline \end{array} $$

$$ \begin{array}{lll} {}_{0}x_{0\cdot5} = 272{\cdot}9 \text{ feet}; & {}_{0}y_{0\cdot5} = 1{\cdot}193 \text{ feet}; & {}_{0}t_{0\cdot5} = 0''.2722 \\ {}_{0\cdot5}x_{1} = 244{\cdot}2\ \ \text{,,}\ ; & {}_{0\cdot5}y_{1} = 3{\cdot}201\ \ \text{,,}\ ; & {}_{0\cdot5}t_{1} = 0\ {\cdot}2579 \\ {}_{1}x_{1\cdot3} = 135{\cdot}1\ \ \text{,,}\ ; & {}_{1}y_{1\cdot3} = 2{\cdot}711\ \ \text{,,}\ ; & {}_{1}t_{1\cdot3} = 0\ {\cdot}1483 \\ \hline {}_{0}x_{1\cdot3} = 652{\cdot}2 & {}_{0}y_{1\cdot3} = -7{\cdot}105 & {}_{0}t_{1\cdot3} = 0\ {\cdot}6784 \\ {}_{1}x_{0} = 735{\cdot}1 & {}_{1}y_{0} = +6{\cdot}843 & {}_{1}t_{0} = 0\ {\cdot}6299 \\ \hline \quad 1387{\cdot}3 & \quad -0{\cdot}262 & \quad 1\ {\cdot}3083 \\ \hline \end{array} $$

Correction for y is $-0{\cdot}262$, for x is $-0{\cdot}262 \cot 1^\circ{\cdot}3 = -11{\cdot}5$, and for t is $-0''{\cdot}0128$. Therefore, the range is $1387{\cdot}3 - 11{\cdot}5 = 1375{\cdot}8$ feet; the greatest height is $6{\cdot}843$ feet; and the time of flight is $1''{\cdot}3083 - 0''{\cdot}0128 = 1''{\cdot}2955$.

Or, if we divide the trajectory into two parts at the vertex, we find $u_0 = 1034{\cdot}5\,f.s$; $v'_{1\cdot3} = 900\,f.s$; ${}_{1}s_{0} = 736{\cdot}0$ feet; ${}_{0}s_{1\cdot3} = 651{\cdot}3$ feet; and

$$ \begin{array}{lll} {}_{1}x_{0} = 735{\cdot}9 \text{ feet}; & {}_{1}y_{0} = +6{\cdot}440 \text{ feet}; & {}_{1}t_{0} = 0''{\cdot}6308 \\ {}_{0}x_{1\cdot3} = 651{\cdot}2\ \ \text{,,}\ ; & {}_{0}y_{1\cdot3} = -7{\cdot}390\ \ \text{,,}\ ; & {}_{0}t_{1\cdot3} = 0''{\cdot}6776 \\ \hline \quad 1387{\cdot}1 & \quad -0{\cdot}950 & \quad 1''{\cdot}3084 \\ \hline \end{array} $$

120. If we suppose OP to be the arc of a circle, then $\angle PON=\frac{1}{2}(\alpha+\beta)$, and therefore ${}_{a}x_{\beta}={}_{a}s_{\beta}\cos\frac{1}{2}(\alpha+\beta)$, and ${}_{a}y_{\beta}={}_{a}s_{\beta}\sin\frac{1}{2}(\alpha+\beta)$. Thus we find

$$\begin{array}{lll}
{}_{1}x_{0\cdot5}=416\cdot5\text{ feet}; & {}_{1}y_{0\cdot5}=5\cdot451\text{ feet}; & {}_{1}t_{0\cdot5}=0''\cdot3359 \\
{}_{0\cdot5}x_{0}=318\cdot8\quad ,,\ ; & {}_{0\cdot5}y_{0}=1\cdot391\quad ,,\ ; & {}_{0\cdot5}t_{0}=0\ \cdot2940 \\
\hline
{}_{1}x_{0}=735\cdot3\quad ,, & {}_{1}y_{0}=+6\cdot842 & {}_{1}t_{0}=0''\cdot6299 \\
\hline
\end{array}$$

and

$$\begin{array}{lll}
{}_{0}x_{0\cdot5}=272\cdot9\text{ feet}; & {}_{0}y_{0\cdot5}=\ 1\cdot191\text{ feet}; & {}_{0}t_{0\cdot5}=0''\cdot2722 \\
{}_{0\cdot5}x_{1}=244\cdot2\quad ,,\ ; & {}_{0\cdot5}y_{1}=\ 3\cdot196\quad ,,\ ; & {}_{0\cdot5}t_{1}=0\ \cdot2578 \\
{}_{1}x_{1\cdot3}=135\cdot0\quad ,,\ ; & {}_{1}y_{1\cdot3}=\ 2\cdot711\quad ,,\ ; & {}_{1}t_{1\cdot3}=0\ \cdot1483 \\
\hline
{}_{0}x_{1\cdot3}=652\cdot1 & {}_{0}y_{1\cdot3}=-7\cdot098 & {}_{0}t_{1\cdot3}=0''\cdot6784 \\
{}_{1}x_{0}=735\cdot3 & {}_{1}y_{0}=+6\cdot842 & {}_{1}t_{0}=0\ \cdot6299 \\
\hline
1387\cdot4 & -0\cdot256 & 1''\cdot3083 \\
\hline
\end{array}$$

Hence the range on the horizontal plane through the point of projection is $1387\cdot4-0\cdot256\cot 1^{\circ}\cdot3=1387\cdot4-11\cdot3=1376\cdot1$ feet; and the time of flight $1''\cdot3083-0''\cdot0126=1''\cdot2957$.

Or, if we divide the trajectory into two parts at the vertex, we obtain

$$\begin{array}{lll}
{}_{1}x_{0}\ =736\cdot0\text{ feet}; & {}_{1}y_{0}\ =+6\cdot423 & {}_{1}t_{0}\ =0''\cdot6308 \\
{}_{0}x_{1\cdot3}=651\cdot3\quad ,,\ ; & {}_{0}y_{1\cdot3}=-7\cdot390 & {}_{0}t_{1\cdot3}=0\ \cdot6776 \\
\hline
1387\cdot3 & -0\cdot967 & 1\ \cdot3084 \\
\hline
\end{array}$$

Mr. W. D. Niven has shewn how to apply corrections to the angle $\frac{1}{2}(\alpha+\beta)$, so that by the help of the general Tables L. and M. trajectories may be approximately calculated in the absence of the tabular numbers X, Y and T.

121. The Tables of values of X, Y and T, or X', Y' and T', for $\gamma=13\cdot0$ to $\gamma=\infty$ have been calculated for the *descending* branch only of the trajectory. But if it should be necessary to calculate the ascending branch in any of these cases, then, as the inclination of the tangent of the trajectory to the horizon cannot much exceed 1° 30′, one of the above simple methods would apply and must be used up to the vertex. After that the tables of values of X, Y and T, or of X', Y' and T' may be used to complete the calculation of the trajectory from the vertex downwards.

122. Suppose it to be required to calculate the trajectory of a 70 lb. ogival-headed shot fired from the 6·3-inch howitzer, with a muzzle velocity of 751 *f.s* at an elevation of 30°. Here $d = 6{\cdot}27$ in. and $d^2 \div w = {\cdot}5616$. We will divide the trajectory into arcs $30° - 28°$, $28° - 24°$, $24° - 20°$, &c. Calculate the velocities v_{28}, v_{24}, v_{20}, &c., by the help of Table J.

Generally $R_{u_\beta} \sec\alpha = R_{v_\alpha} - \frac{d^2}{w}(P_\alpha - P_\beta)\cos^3\alpha$ for the ascending branch (117),

or $$R_{u_{28}} \sec 30° = R_{751} - {\cdot}5616\,(P_{30} - P_{28})\cos^3 30°$$

$$= 7{\cdot}6109 - 0{\cdot}0653 = 7{\cdot}5456 = R_{734{\cdot}5},$$

or $$u_{28} \sec 30° = 734{\cdot}5, \quad u_{28} = 636{\cdot}1, \text{ and } v_{28} = 720{\cdot}4\, f.s.$$

Again $$R_{u_{24}} \sec 28° = R_{v_{28}} - \frac{d^2}{w}(P_{28} - P_{24})\cos^3 28°$$

$$= 7{\cdot}4864 - 0{\cdot}1243 = 7{\cdot}3621 = R_{693{\cdot}4},$$

or $$u_{24} \sec 28° = 693{\cdot}4,\ u_{24} = 612{\cdot}2, \text{ and } v_{24} = 670{\cdot}2\, f.s.$$

ϕ	v			u			γ	
	f.s	Δ_1	Δ_2	*f.s*	Δ_1	Δ_2		Δ_1
30°	751·0			650·4				
							·223	
28	720·4			636·1				
		− 50·2			− 23·9		·231	
24	670·2		+ 10·5	612·2		+ 4·2		+ 11
		− 39·7			− 19·7		·242	
20	630·5		+ 8·1	592·5		+ 2·9		+ 11
		− 31·6			− 16·8		·253	
16	598·9		+ 6·2	575·7		+ 2·1		+ 11
		− 25·4			− 14·7		·264	
12	573·5		+ 5·0	561·0		+ 1·5		+ 10
		− 20·4			− 13·2		·274	
8	553·1		+ 4·3	547·8		+ 1·1		+ 8
		− 16·1			− 12·1		·282	
+ 4	537·0		+ 3·7	535·7		+ 1·0		+ 8
		− 12·4			− 11·1		·290	
0	524·6		+ 3·3	524·6		+ 0·9		+ 6
		− 9·1			− 10·2		·296	
− 4	515·5		+ 2·9	514·4		+ 0·1		+ 5
		− 6·2			− 10·1		·301	
8	509·3		+ 2·6	504·3		+ 0·4		+ 3
		− 3·6			− 9·7		·304	
12	505·7		+ 2·6	494·6		+ 0·2		+ 1
		− 1·0			− 9·5		·305	
16	504·7		+ 2·5	485·1		+ 0·1		0
		+ 1·5			− 9·4		·305	
20	506·2		+ 2·5	475·7		− 0·2		− 2
		+ 4·0			− 9·6		·303	
24	510·2		+ 2·6	466·1		− 0·2		− 3
		+ 6·6			− 9·8		·300	
28	516·8		+ 2·5	456·3		− 0·5		− 6
		+ 9·1			− 10·3		·294	
32	525·9		+ 2·9	446·0		− 0·5		− 9
		+ 12·0			− 10·8		·285	
36	537·9		+ 2·9	435·2				− 12
		+ 14·9					·273	
40	552·8							

Again $R_{u_{20}\sec 24°} = \mathrm{R}_{v_{24}} - \frac{d^2}{w}(P_{24} - P_{20}) \cos^3 24°$

$$= 7·2435 - 0·1215 = 7·1220 = R_{648·6},$$

or $u_{20} \sec 24° = 648·6$, $u_{20} = 592·5$, and $v_{20} = 630·5$ *f.s.*&c.

To test the accuracy of the calculations as we proceed we difference the values of v, u, and also γ when calculated, as in the above Table.

123. It is convenient to find by interpolation values of v corresponding to $\phi = 26°$, 22° &c. Thus we obtain

ϕ	v *f.s*			
30°	751·0			
		−30·6		
28	720·4		+4·0	
		−26·6		−1·0
26	693·8		+3·0	
		−23·6		−0·4
24	670·2		+2·6	
		−21·0		−0·3
22	649·2		+2·3	
		−18·7		
20	630·5			
...	...			

These interpolated velocities may be used as guides to the proper values of $K \div g$ to be used in calculating Δx, Δy and Δt for each arc.

124. We must now proceed to find u_0, and thence γ, Δx, Δy and Δt for each arc. Here

$$\left(\frac{1000}{u_0}\right)^3 = \left(\frac{1000}{u_{28}}\right)^3 + \frac{K}{g}\frac{d^2}{w}P_2$$

$$= \left(\frac{1000}{636·1}\right)^3 + 2·519 \times ·5616 \times 1·74545, \text{ \&c.}$$

Also $\gamma = \left(\frac{u_0}{1000}\right)^3 \frac{K}{g}\frac{d^2}{w}$, and then Δx, Δy and Δt may be found for the arc $(30° - 28°)$, and so on for the remaining arcs of the trajectory. We thus obtain the columns headed Δx, Δy and Δt, which are also to be differenced as the work proceeds to test their correctness. Afterwards the columns x, y and t are found by addition commencing from zero at the vertex in each case, as in the table following:

φ	x feet	Δx	Δ²x	Δ³x	y feet	Δy	Δ²y	Δ³y	t	Δt	Δ²t	Δ³t
30°	6074	− 593			1882	− 329			10″·413	− 0″·916		
28	5481	− 1055			1553	− 516			9 ·497	− 1 ·682		
24	4426	− 920	+ 135	− 35	1037	− 373	+ 143	− 37	7 ·815	− 1 ·523	+ 159	− 39
20	3506	− 820	+ 100	− 25	664	− 267	+ 106	− 25	6 ·292	− 1 ·403	+ 120	− 27
16	2686	− 745	+ 75	− 18	397·3	− 186·3	+ 81	− 16	4 ·889	− 1 ·310	+ 93	− 23
12	1941	− 688	+ 57	− 12	211·0	− 121·6	+ 64·7	− 11·0	3 ·579	− 1 ·240	+ 70	− 18
8	1253	− 643	+ 45	− 12	89·4	− 67·9	+ 53·7	− 7·3	2 ·339	− 1 ·188	+ 52	− 15
+ 4	610	− 610	+ 33	− 9	+ 21·5	− 21·5	+ 46·4	− 4·6	+1 ·151	− 1 ·151	+ 37	− 14
0	0	− 586	+ 24	− 7	0	+ 20·3	+ 41·8	− 2·3	0	− 1 ·128	+ 23	− 12
− 4	586	− 569	+ 17	− 6	+ 20·3	+ 59·8	+ 39·5	− 0·9	−1 ·128	− 1 ·117	+ 11	− 11
8	1155	− 558	+ 11	− 6	80·1	+ 98·4	+ 38·6	+ 0·9	2 ·245	− 1 ·117	0	− 12
12	1713	− 553	+ 5	− 6	178·5	+ 137·9	+ 39·5	+ 2·6	3 ·362	− 1 ·129	− 12	− 12
16	2266	− 554	− 1	− 5	316·4	+ 180·0	+ 42·1	+ 4·2	4 ·491	− 1 ·153	− 24	− 12
20	2820	− 560	− 6	− 5	496·4	+ 226·3	+ 46·3	+ 6·1	5 ·644	− 1 ·189	− 36	− 14
24	3380	− 571	− 11	− 7	722·7	+ 278·7	+ 52·4	+ 9·3	6 ·833	− 1 ·239	− 50	− 17
28	3951	− 589	− 18	− 7	1001·4	+ 340·4	+ 61·7	+ 12·3	8 ·072	− 1 ·306	− 67	− 19
32	4540	− 614	− 25	− 8	1341·8	+ 414·4	+ 74·0	+ 17·1	9 ·378	− 1 ·392	− 86	− 25
36	5154	− 646	− 32		1756·2	+ 505·5	+ 91·1		10 ·770	− 1 ·503	− 111	
40	5800				2261·7				12 ·273			

125. We might now find the range, time of flight, final velocity and angle of descent on a horizontal plane, a given distance above or below the muzzle of the gun. But we can derive other important results from the calculations already made, which will be of great service when we come to the systematic calculation of Range Tables. Any point in the trajectory may be considered to be the point of projection, provided the shot be supposed to be projected with the velocity, and in the direction of the tangent to the trajectory, at that point. We shall, therefore, suppose that shot are fired at elevations of 0, 4°, 8°, 12°, &c., with muzzle velocities 537·0, 553·1, 573·5, &c., *f.s* respectively, and find their ranges, &c., on horizontal planes 6·5 feet below the points of projection. It will be advisable to find by interpolation the values of x', y', t' and v' in the *descending* branch for values 1°, 2°, 3°, &c. of ϕ'. The following is small portion of such a table:

ϕ'	v' *f.s*	Δ	x' feet	Δ	y' feet	Δ		t'	Δ
...	...		...		...			...	
20°	506·2	+0·8	2820	+139	496·4	+52·0		5″·644	+·293
21	507·0	0·9	2959	140	548·4	55·0	3·0	5 ·937	·296
22	507·9	1·1	3099	140	603·4	58·1	3·1	6 ·233	·299
23	509·0	1·2	3239	141	661·5	61·2	3·1	6 ·532	·301
24	510·2		3380		722·7			6 ·833	
...	...		...		...			...	

126. When the gun is supposed to be elevated 20° above the horizon the corresponding muzzle velocity of the shot is 630·5 *f.s* (122). The shot rises 664·0+6·5=670·5 feet above the horizontal plane on which we desire to find the range, &c. By the help of the above table we find that when the shot is moving in the descending branch of the trajectory in a direction inclined to the horizon at 23°, it has fallen through a vertical height of 661·5 feet, and when at 24°, it has fallen through a vertical height of 722·7 feet. We desire to find ϕ', x', t', v' corresponding to $y' = 670{\cdot}5$. Hence

$$\phi' = 23° + (670{\cdot}5 - 661{\cdot}5) \div 61{\cdot}2 \times 1° = 23° + 9° \div 61{\cdot}2 = 23°{\cdot}15\,;$$

$$x' = 3239 + (9 \div 61{\cdot}2) \times 141 = 3239 + 21 = 3260 \text{ feet};$$

$$t' = 6''{\cdot}532 + (9 \div 61{\cdot}2) \times 0''{\cdot}301 = 6''{\cdot}532 + 0''{\cdot}044 = 6''{\cdot}576\,;$$

$$\text{v}' = 509{\cdot}0 + (9 \div 61{\cdot}2) \times 1{\cdot}2 = 509{\cdot}0 + 0{\cdot}2 = 509{\cdot}2\,f.s.$$

Hence $\text{V} = 630{\cdot}5\,f.s$; $\text{R} = 3506 + 3260 = 6766$ feet $= 2255$ yards; $\text{Y} = -6{\cdot}5$ feet;

$$\text{T} = 6''{\cdot}292 + 6''{\cdot}576 = 12''{\cdot}868;\quad \Phi' = 23^\circ{\cdot}15;\ \text{and } \text{V}' = 509{\cdot}2\,f.s.$$

In the same way we proceed to calculate the ranges, times of flight, &c., for elevations of 0°, 4°, 8°...28° and 30° and obtain the following results:

Φ	V f.s	R yards	Δ₁	Δ₂	Y′ feet	Δ₁	Δ₂	Δ₃	T	Δ₁	Δ₂	Φ′	Δ₁	Δ₂	V′ f.s	Δ₁	Δ₂
0°	524·6	109	+ 322		6·5	+ 21·5			0″·63	+ 2·84		2°·22	+ 2·46		519·1	− 4·8	
4	537·0	431	+ 407	+ 85	28·0	+ 67·9	+ 46·4	+ 7·3	2″·47	+ 2·32	− ·52	4 ·68	+ 4·07	+ 1·61	514·3	− 5·8	− 1·0
8	553·1	838	+ 438	+ 31	95·9	+ 121·6	+ 53·7	+ 11·0	4 ·79	+ 2·50	+ ·18	8 ·75	+ 4·50	+ ·43	508·5	− 3·4	+ 2·4
12	573·5	1276	+ 470	+ 32	217·5	+ 186·3	+ 64·7	+ 15·7	7 ·29	+ 2·68	+ ·18	13 ·25	+ 4·81	+ ·31	505·1	·0	+ 3·4
16	598·9	1746	+ 509	+ 39	403·8	+ 266·7	+ 80·4	+ 25·9	9 ·97	+ 2·90	+ ·22	18 ·06	+ 5·09	+ ·28	505·1	+ 4·1	+ 4·1
20	630·5	2255	+ 563	+ 54	670·5	+ 373·0	+ 106·3	+ 36·7	12 ·87	+ 3·19	+ ·29	23 ·15	+ 5·38	+ ·29	509·2	+ 8·7	+ 4·6
24	670·2	2818	+ 633	+ 70	1043·5	+ 516·0	+ 143·0		16 ·06	+ 3·57	+ ·38	28 ·53	+ 5·67	+ ·29	517·9	+ 14·2	+ 5·5
28	720·4	3451			1559·5				19 ·63			34 ·20			532·1		
30	751·0	3802			1888·5				21 ·59			37·12			541·8		

127. By interpolation we can now find the values of V, R, Y′, T, Φ′ and V′ for Φ = 1°, 2°, 3°...28°, 29°, 30°, as follows:

Φ	V *f.s*		R yards		Y′ feet	T		Φ′		V′ *f.s.*	
...	...		...		...	...		...	...	...	...
24°	670·2	+11·5	2818	+150	1043·5	16″·06	+ ·85	28°·53	1.39	517·9	+3·0
25	681·7	+12·1	2968	+156	1157·5	16 ·91	+ ·88	29 ·92	1·41	520·9	+3·3
26	693·8	+12·9	3124	+161	1280·5	17 ·79	+ ·91	31 ·33	1·43	524·2	+3·7
27	706·7	+13·7	3285	+166	1414·0	18 ·70	+ ·93	32 ·76	1·44	527·9	+4·2
28	720·4	+14·7	3451	+172	1559·5	19 ·63	+ ·96	34 ·20	1·45	532·1	+4·6
29	735·1	+15·9	3623	+179	1717·5	20 ·59	+1·00	35 ·65	1·47	536·7	+5·1
30	751·0		3802		1888·5	21 ·59		37 ·12		541·8	

128. In the next place suppose that we wish to calculate the Range, &c. of the shot for a muzzle velocity of 751 *f.s*, and an elevation of 30° in a more expeditious manner. After having found by calculation as above, $u_0 = 524{\cdot}6$ *f.s* and $v'_{37} = 541{\cdot}4$ *f.s*, we will divide the trajectory into two parts at the vertex. The mean value of $K \div g$ found by the help of the table of values of $\Sigma(K \div g)$ between 750 and 525 *f.s*, is 2·961. This gives $\gamma = 0{\cdot}2401$; ${}_{30}x_0 = 5947$ feet; ${}_{30}y_0 = 1836{\cdot}7$ feet; and ${}_{30}t_0 = 10''{\cdot}304$.

In the descending branch the shot has to fall a vertical height of $1836{\cdot}7 + 6{\cdot}5 = 1843{\cdot}2$ feet. The mean value of $K \div g$ between velocities 525 and 540 *f.s* is 3·555, which gives $\gamma = 0{\cdot}288$ and

$${}_0x_{36} = 5179{\cdot}8 \text{ feet}; \quad {}_0y_{36} = -1768{\cdot}2 \text{ feet}; \quad {}_0t_{36} = 10''{\cdot}797,$$

$${}_0x_{37} = 5338{\cdot}6 \;\;,, \;; \quad {}_0y_{37} = -1885{\cdot}8 \;\;,, \;; \quad {}_0t_{37} = 11\ {\cdot}162.$$

Hence

$${}_0x_{36\,64} = 5281 \text{ feet}; \quad {}_0y_{36\,64} = -1843{\cdot}2 \text{ feet}; \quad {}_0t_{36\cdot64} = 11''{\cdot}030,$$

$${}_{30}x_0 = 5947 \;\;,, \;; \quad {}_{30}y_0 = +1836{\cdot}7 \;\;,, \;; \quad {}_{30}t_0 = 10\ {\cdot}304.$$

Therefore, R = 11228 feet = 3743 yards. Y = − 6·5 feet. And T = 21″·33.

129. Lastly we will find u_0 and v'_{36} by the formula *A* (114). The initial velocity is 751 *f.s*, and we are certain that this will be very much reduced when it reaches the vertex of the trajectory. We will assume $K \div g = 2{\cdot}905$, which corresponds to a mean velocity of 640 *f.s*. Substituting in formula *A* (114) we find $\mathrm{u}_0 = 528{\cdot}5$ *f.s* a first approximation. By the help of the table of values of $\Sigma\,(K \div g)$, we find the mean value of $K \div g$ between velocities 750 and 530 *f.s* $= 2{\cdot}946$. This gives $\mathrm{u}'_0 = 527{\cdot}4$ *f.s*. a second approximation. The mean value of $K \div g$ between 751 and 527·4 *f.s* will be found to be 2·951. And it has been found that

$$K \div g = 2{\cdot}905 \text{ gave } \mathrm{u}_0 = 528{\cdot}5\,f.s,$$

and $$K \div g = \underline{2{\cdot}946} \text{ gave } \mathrm{u}'_0 = \underline{527{\cdot}4}\,f.s,$$

or $$+{\cdot}041 \text{ gave } \quad -0{\cdot}9$$

Therefore $$+{\cdot}005 \text{ would give} -0{\cdot}1,$$

or $K \div g = 2{\cdot}951$ would give $u_0 = 527{\cdot}3$. This gives $\gamma = 0{\cdot}2428$, ${}_{30}x_0 = 6023{\cdot}0$ feet, ${}_{30}y_0 = 1862{\cdot}2$ feet, and ${}_{30}t_0 = 10''{\cdot}369$.

For the descending branch mean value of $K \div g$ between velocities 527 and 540 *f.s* will be found to be 3·554, which gives $\gamma = 0{\cdot}2925$ and

$${}_0x_{36} = 5218{\cdot}3 \text{ feet}; \; {}_0y_{36} = 1779{\cdot}8 \text{ feet}; \text{ and } {}_0t_{36} = 10''{\cdot}837,$$

$${}_0x_{37} = 5378{\cdot}0 \;\; ,, \; ; \; {}_0y_{37} = 1898{\cdot}0 \;\; ,, \; ; \qquad {}_0t_{37} = 11 \;{\cdot}203.$$

The vertical height through which the projectile has to descend is $1862{\cdot}2 + 6{\cdot}5 = 1868{\cdot}7$ feet, from which consideration we obtain,

$${}_0x_{36\cdot75} = 5338{\cdot}4 \text{ feet}; \; {}_0y_{36\cdot75} = -1868{\cdot}7 \text{ feet}; \text{ and } {}_0t_{36\cdot75} = 11''{\cdot}112,$$

and

$${}_{30}x_0 = 6023{\cdot}0 \;\; ,, \; ; \; {}_{30}y_0 = +1862{\cdot}2 \;\; ,, \; ; \text{ and } \; {}_{30}t_0 = 10 \;{\cdot}369.$$

Hence $\mathrm{X} = 11361$ feet $= 3787$ yards; $\mathrm{Y} = -6{\cdot}5$ feet;

and $$\mathrm{T} = 21''{\cdot}481.$$

130. A somewhat more accurate result would have been obtained if the descending branch had been divided into two sections at the point where v' is a minimum. Differentiating

$$u'^{-3} = u_0^{-3}\,\{1 + \gamma\,(3\tan\phi' + \tan^3\phi')\}$$

or $$v'^{-3} = u_0^{-3}\,\{\cos^3\phi' + \gamma\,(3\sin\phi'\cos^2\phi' + \sin^3\phi')\},$$

we find $\tan 2\phi' = 2\gamma = 0{\cdot}582 = \tan 30^\circ$ nearly. Or the descending branch may be divided into two arcs, 0 to -15°, and -15° to -37°.

131. On sending in my report on the additional experiments 1878-9, undertaken to determine the resistance of the air to projectiles moving at very *high* and very *low* velocities, some range tables of the 6·3-inch howitzer were forwarded to me from Woolwich because they appeared to shew that my coefficients did not give the same final velocities as were recorded in those range tables. But as those were cases were the muzzle velocities were *low*, and the elevations were often *high*, the trajectories of the shot were mostly much curved, so that the general tables connecting v, s and t did not apply. I therefore decided to calculate the trajectories carefully, so as to compare the results of calculation and experiment for low velocities in a thoroughly satisfactory manner in this case, which was not of my own choosing. The range tables were arranged to shew what elevation must be given to the howitzer in order to obtain ranges of 400, 500, 600, &c., yards with charges of 1, 2, 3, $3\frac{1}{4}$, $3\frac{1}{2}$, $3\frac{3}{4}$ and 4 lbs. of powder. But it was easy to deduce from these tables the ranges, times of flight, final velocities and angles of descent for elevations of 5°, 10°, 15°, 20°, &c., corresponding to the various muzzle velocities given with each of the specified charges.

132. In these calculations $w = 70$ lbs.; $d = 6{\cdot}27$ inches; and $d^2 \div w = 0{\cdot}5616$. The calculation of the velocities commenced from the vertex with values of $u_0 = 100$, 140, 180, 220...700, 740 *f.s.* The formula used was

$$R_{v_\beta} = R_{v_\alpha \cos\alpha \sec\beta} \pm \frac{d^2}{w}(P_\beta - P_\alpha)\cos^3\beta,$$

where it is manifest that $\frac{d^2}{w}(P_\beta - P_\alpha)\cos^3\beta$ having been calculated for one trajectory at intervals of 5°, the result would be applicable to all the other trajectories to be calculated. As has been explained (126) the ranges, &c., were calculated for each of the above specified values of u_0 for elevations of 5°, 10°, 15°...45°.

133. Afterwards values of V_5, R_5, T_5 and Φ'_5 were arranged in tables where u_0 was the argument. Then seven intermediate values of these quantities were found by interpolation. The same thing was done with V_{10}, R_{10}, T_{10} and Φ'_{10}, and so on for elevations of 15°, 20°...45°.

The following is a specimen of the table for an elevation of $\Phi = 30^\circ$:

u_0 f.s	V f.s	Δ	R yards	Δ	Y′ feet	T	Δ	Φ′	Δ	v′ f.s	Δ
...	...		...		...	...		...		...	
300	367·2	+6·9	1122	+39	509·5	11″·21	+·20	32°·06	+·05	334·6	+5·1
305	374·1	6·9	1161	39		11 ·41	20	32 ·11	6	339·7	5·1
310	381·0	7·0	1200	41		11 ·61	20	32 ·17	6	344·8	5·1
315	388·0	7·0	1241	41		11 ·81	20	32 ·23	7	349·9	5·1
320	395·0	7·1	1282	42		12 ·01	20	32 ·30	7	355·0	5·1
325	402·1	7·2	1324	43		12 ·21	21	32 ·37	7	360·1	5·0
330	409·3	7·3	1367	44		12 ·42	21	32 ·44	7	365·1	5·0
335	416·6	7·3	1411	45		12 ·63	21	32 ·51	8	370·1	5·0
340	423·9	7·4	1456	46	667·5	12 ·84	21	32 ·59	8	375·1	5·0
345	431·3	7·4	1502	46		13 ·05	21	32 ·67	9	380·1	5·0
350	438·7	7·5	1548	48		13 ·26	21	32 ·76	9	385·1	5·0
355	446·2	7·6	1596	48		13 ·47	22	32 ·85	9	390·1	4·9
360	453·8	7·7	1644	50		13 ·69	21	32 ·94	9	395·0	4·9
365	461·5	7·7	1694	50		13 ·90	22	33 ·03	10	399·9	4·8
370	469·2	7·8	1744	51		14 ·12	22	33 ·13	10	404·7	4·8
375	477·0	7·9	1795	52		14 ·34	22	33 ·23	10	409·5	4·8
380	484·9	8·0	1847	53	856·5	14 ·56	22	33 ·33	10	414·3	4·7
385	492·9		1900			14 ·78		33 ·43		419·0	
...	...		...		...	...		...		...	
540	784·4		4067		2038·5	22·42		37 ·61		554·2	

134. It is easy to find from this Table the range, &c. of the 6·3-inch howitzer corresponding to any muzzle velocity between 360 and 500 *f.s* for an elevation of 30°. For instance, suppose the muzzle velocity given is 450 *f.s*, a velocity not found in the Table. We must, therefore, make use of proportional parts.

The muzzle velocity is

$$(446{\cdot}2 + 3{\cdot}8) f.s.$$

The range R is

$$1596 + 48 \times (3{\cdot}8 \div 7{\cdot}6) = 1596 + 24 = 1620 \text{ yards.}$$

The time of flight T is

$$13''{\cdot}47 + {\cdot}22 \times (3{\cdot}8 \div 7{\cdot}6) = 13''{\cdot}47 + 0''{\cdot}11 = 13''{\cdot}58.$$

The angle of descent Φ' is

$$32^\circ{\cdot}85 + {\cdot}09\,(3{\cdot}8 \div 7{\cdot}6) = 32^\circ{\cdot}85 + 0^\circ{\cdot}05 = 32^\circ{\cdot}90.$$

And the final velocity v' is

$$390{\cdot}1 + 4{\cdot}9\,(3{\cdot}8 \div 7{\cdot}6) = 390{\cdot}1 + 2{\cdot}5 = 392{\cdot}6 f.s.$$

And the like may be done with the other tables for elevations of 5°, 10°, &c., which will be sufficient when the object is merely to compare the results of calculation with those given in Range Tables.

135. But if the object be to calculate the elevations to be given to the gun, with a known muzzle velocity, in order to obtain ranges of 400, 500, 600, &c. yards; first find, as above, from the Tables calculated, the Ranges, &c. for elevations of 0, 5°, 10°, 15°, &c. corresponding to the given muzzle velocity. Then find the like quantities by interpolation for elevations

Φ	R yards	Δ	T	Δ	Φ'	Δ	v'	Δ
...	...		...		...		...	
15°	2462	+123	11″·56	+72	17°·64	+1·31	593	−6
16	2585	118	12 ·28	71	18 ·95	1·31	587	6
17	2703	113	12 ·99	70	20 ·26	1·31	581	6
18	2816	108	13 ·69	70	21 ·57	1·31	575	5
19	2924	103	14 ·39	69	22 ·88	1·31	570	4
20	3027	98	15 ·08	68	24 ·19	1·31	566	4
21	3125	94	15 ·76	67	25 ·50	1·31	562	4
22	3219	89	16 ·43	67	26 ·81	1·31	558	3
23	3308	85	17 ·10	66	28 ·12	1·31	555	3
24	3393	80	17 ·76	66	29 ·43	1·31	552	2
25	3473		18 ·42		30 ·74		550	
...	...		...		...		...	

of 1°, 2°, 3°, &c. It will then be easy by the use of proportional parts to find the elevations to be given in order to obtain any possible range. Thus suppose the muzzle velocity of the 6·3-inch howitzer to be 751 *f.s*, then we obtain from the Tables already calculated the values of R, T, Φ' and v' corresponding to $\Phi = \ldots 15°, 20°, 25° \ldots$, and interpolate, as in the preceding table.

136. We can now calculate Φ, T, Φ' and v', corresponding to ranges of 2500, 2600, &c. yards, and we obtain for $v = 751$ *f.s*,

R yards	Φ	Δ	T	Δ	Φ'	Δ	v' *f.s*	Δ
...	...		...		...		...	
2500	15°·31	+·82	11″·78	+0″·59	18°·05	+1·07	591	−5
2600	16 ·13	·84	12 ·37	·60	19 ·12	1·11	586	5
2700	16 ·97	·89	12 ·97	·62	20 ·23	1·15	581	5
2800	17 ·86	·92	13 ·59	·64	21 ·38	1·21	576	5
2900	18 ·78	·96	14 ·23	·66	22 ·59	1·26	571	4
3000	19 ·74	1·00	14 ·89	·70	23 ·85	1·31	567	4
3100	20 ·74	1·06	15 ·59	·71	25 ·16	1·38	563	4
3200	21 ·80	1·11	16 ·30	·74	26 ·54	1·46	559	4
3300	22 ·91	1·20	17 ·04	·80	28 ·00	1·58	555	3
3400	24 ·11		17 ·84		29 ·58		552	
...	...		...		...		...	

which may be compared with the Range Table for a charge of 4 lbs. given in *Instructions for Field Service*, 1879, p. 103.

137. In this way numerous comparisons of calculated and experimental ranges, &c. for low muzzle velocities, have been made by the help of Range Tables, both English and German, (100). Considering all the uncertainties which attach to such Tables, the results appear to be as satisfactory as could be reasonably expected.

138. If it had been desired to provide means for the ready preparation of theoretical Range Tables for any practical value of $d^2 \div w$ whatever, then it would be necessary to calculate sets of Tables, for values 0·1, 0·3, 0·5, &c. of $d^2 \div w$, such as we have calculated for $d^2 \div w = 0{\cdot}5616$; or, with a view to utilise the work already done, $d^2 \div w$ might be taken equal $0{\cdot}5616 \pm 0{\cdot}2000 \times n$. The trajectories were calculated by arcs of 5°, but the results would have been a trifle more precise, and the interpolations much simplified, if arcs of 4 had been used.

139. Inasmuch as the unit of the value of K depends upon something like the 1-100000th of a second (105), it was, perhaps, needless to express its value to one place of decimals. This affords an additional explanation of the observed fact, that a small error in the numerical value of K does not produce errors of much importance in the calculation of trajectories in practical cases. In the reduction of the experiments and in the calculation of the Tables, the Arithmometer of Thomas (de Colmar) has proved a most valuable assistant.

140. In making systematic calculations of trajectories printed forms were found of great assistance; and the recent invention for producing manifold copies of writing renders it easy for any one to prepare his own forms. Tables of five figure logarithms are quite sufficient for these calculations, while Tables of *four* figures may be used for many purposes; and some proportions can be worked by the slide rule with sufficient accuracy.

Supplementary Tables.

Tables printed 1877.

A. Continuation of Table VI. for values of $\gamma = 5{\cdot}1$ to $\gamma = 100$.

B. Continuation of Table A from $\gamma = 100$ to $\gamma = \infty$.

C. Tables of values of K_v, $K_v \div g$, &c. (This Table, as well as Table I. are now superseded by Table H.)

D. Table of values of P_ϕ for every tenth of a degree from 0 to 21°.

E. Table of values of (v versin ϕ) useful in calculating u from a given value of v and ϕ, or v from a given value of u and ϕ without the use of logarithms, thus

$$u = v \cos\phi = v - v \operatorname{vers}\phi \;\ldots\ldots\ldots\ldots\ldots\ldots\; (1),$$

and

$$v = u + v \operatorname{vers}\phi = u + (u + v \operatorname{vers}\phi) \operatorname{vers}\phi$$
$$= u + u \operatorname{vers}\phi + (u \operatorname{vers}\phi) \operatorname{vers}\phi \text{ nearly}\ldots(2).$$

Example (71)

$$u_6 = 1335 - 1335 \operatorname{vers} 5^\circ = 1335{\cdot}0 - 4{\cdot}95 - {\cdot}13$$
$$= 1335{\cdot}0 - 5{\cdot}08 = 1329{\cdot}9.$$

Again

$$v_5 = 1329{\cdot}9 + 1329{\cdot}9 \operatorname{vers} 5^\circ + (1329{\cdot}9 \operatorname{vers} 5^\circ) \operatorname{vers} 5^\circ$$
$$= 1329{\cdot}9 + 5{\cdot}06 + 5{\cdot}06 \operatorname{vers} 5^\circ$$
$$= 1329{\cdot}9 + 5{\cdot}06 + 0{\cdot}02 = 1335{\cdot}0.$$

Example. $u_{15} = 1450 - 1450 \text{ vers } 15^\circ = 1450 - 49{\cdot}4 = 1400{\cdot}6.$

Again
$$\begin{aligned} v_{15} &= 1400{\cdot}6 + (1400{\cdot}6) \text{ vers } 15^\circ \\ &\quad + (1400{\cdot}6 \text{ vers } 15^\circ) \text{ vers } 15^\circ \\ &= 1400{\cdot}6 + 47{\cdot}7 + 47{\cdot}7 \text{ vers } 15^\circ \\ &= 1400{\cdot}6 + 47{\cdot}7 + 1{\cdot}6 = 1449{\cdot}9. \end{aligned}$$

F. Table of values of $[1000 \div v]^3$ for velocities 500 to 2000 *f.s.*

G. Table of heights in feet, through which a body would descend when falling freely from rest under the action of gravity in the latitude of London in the specified times

Tables printed in 1881.

H. Tables of values of K_v, $K_v \div g$, $\log K_v \div g$, and $\Sigma (K_v \div g)$ for velocities 100 to 2800 *f.s* for ogival-headed projectiles, to supersede Tables I. and C.

J. Table of values of $R_v = (1000)^3 \Sigma \{[(v-1)^{-3} - v^{-3}]\, g \div K_{v-\frac{1}{2}}\}$, where the variation in the density of the air may be taken into account by writing $\frac{d^2}{w}\left(1 \pm \frac{\beta}{30}\right)$ for $\frac{d^2}{w}$ in equations I. and II. (117) just as in (103).

K. Table of values of $[1000 \div v]^3$ in continuation of Table F.

L. General Table of values of T_v for $v = 100$ to 2919 *f.s* to supersede Table IX.

M. General Table of values of S_v for $v = 100$ to 2919 *f.s* to supersede Table VIII.

In Tables L and M the tabular numbers T_v and S_v are now arranged to increase with v, for it is a convenience to have δv, δT_v and δS_v all of the same sign. $\frac{d^2}{w} t = T_{\mathrm{v}} - T_v$ and $\frac{d^2}{w} s = S_{\mathrm{v}} - S_v$, where the velocity of the projectile falls from v to v in the time t and space s (79).

N. Table of values of $\log (P_\phi - P_{\phi-1})$, $\log (P_\phi - P_{\phi-2})$ and $\log (P_\phi - P_{\phi-4})$.

O. Table of values of $\log \cos^3 \phi$.

141. The Committee on Explosives appear to have brought their labours to a conclusion. Two former members of this Committee, Messrs. Abel and Noble, have contributed to the Transactions of the Royal Society (1875) some Researches on Fired Gunpowder, based on results said to have been arrived at by the Committee. But I believe that the details of the experiments from which these results were obtained have not yet been published. On this point the authors remark that they have not space within the limits of their paper to enter upon a discussion of the methods of calculation and correction necessary to arrive at the results tabulated. Notwithstanding this missing link, the Royal Society have considered the paper of such high importance that they have honoured it with two royal medals, one to each of its joint authors. When conferring the second medal, the President of the Royal Society referred to the beautiful invention of the Chronoscope, "by which intervals of time as small as *the one-millionth of a second can be measured*,"*!* (*Nature*, Dec. 9, 1880, p. 139). A reference to the paper commended would have shewn that its authors allowed that in reading a *single record* there would be a probable error of 4 or 5 millionths of a second, even when the instrument was in good working order. But this high degree of accuracy could only be attained by cutting all the primaries as nearly *simultaneously* as possible, which is no test whatever of the accuracy of the instrument *when applied to any useful purpose*, as I have already shewn (9) to (19). The cutting plugs, the toothed wheels, and the stop clock are all left out in that method of "testing," but they are all essential parts of the Chronoscope. *The only way to test the power of such an instrument is to employ it in the actual experiments for which it was designed*, to apply the necessary corrections, and to give the results of numerous trials. It is obvious that the cutting plugs would fail grievously during the *initial* motion of the shot, which is the most trying time to the gun.

142. Messrs. Abel and Noble direct attention to two consecutive rounds fired from the 10-inch gun. In both cases the shot quitted the gun with the same velocity. The chronoscopic records were nearly identical for the two rounds. But the pressures indicated by the gauges differed widely. The pressures on the plug *A*, were 63·4 and 28·0 tons per square inch; at *B*, 41·6 and 29·8; at *C*, 37·0

and 30; at 1, 41·9 and 29·8; and at 4, 25·8 and 19·8 respectively. Although it may be readily admitted that the pressure of the gas at any moment would be greater against the *fixed* parts of the gun than against the *moving* shot, it is difficult to understand how it was that the shot did not show, in some more marked manner, the excessive variation of the pressure inside the bore. But the obvious conclusion is, that the pressure of the gas on the base of a shot is no measure of the pressure it exerts on the bore of the gun. Therefore, as the Chronoscope, at the most, can only determine the motion of the shot, and through that the pressure on the shot, it can be of no use in finding the stress of fired gunpowder on the *gun*, except in simple cases of no real importance.

143. Under these circumstances it might have been hoped that this powder question, after an agitation of some fifteen years, was at last satisfactorily settled. But Sir W. Armstrong complains that his 100-ton gun had failed, although its calculated strength at the point of fracture was far in excess of what a *legitimate* pressure would demand. And on the 16th March, 1880, he declares that "Nothing, in fact, wants investigation so much as this powder question, and until we arrive at *more definite conclusions*, we cannot hope to be altogether free from accident." (Proceedings of the R. A. Institution, July, 1880, p. 197).

144. We may accept the doctrine that there is a considerable variation in the pressure exerted by exploding powder on the bore of a gun, according to the nature of the powder used, or to the manner in which it is fired. Sir W. Armstrong says that "with only 5 lbs. of this smaller powder (R.L.G) mixed with 100 lbs. of pebble, the pressure on the crusher gauges rose to 30 tons, the velocity of the projectile remaining almost the same; so that the extra 12 tons was all *wave action*," (p. 196). Without entering into speculations about "wave action" the simple fact seems to be that the use of a small quantity of fine grained powder causes the pebble powder to explode more rapidly at first, and consequently the pressure rises much higher than when pebble powder is used by itself. Anything which retards the initial motion of the shot, or promotes the rapid explosion of the charge, must commonly have the effect of increasing the stress upon the gun.

145. Now it appears that, to be perfectly satisfactory, guns should be constructed of strength sufficient to resist not only *normal* but all *abnormal* pressures, except those which arise from some such cause as double loading. The experiments should be therefore simplified and confined to attempts to measure the *maximum* pressures exerted by the various powders in and about the powder chamber; and it seems probable that pressure gauges, used with new precautions, would suffice for this object, while the Chronoscope should be rejected as a troublesome and useless encumbrance.

146. The copper cylinders used in the crusher gauges should, in the first instance, be compressed up to at least one-half of the pressure expected at the various points where they were to be used. This would test their quality, and save much useless work that otherwise would have to be done by the powder. After the gun had been fired once I would take out the coppers and carefully measure the length of each, and then return them to their former places, and fire the same charge and shot a second time, and afterwards measure the lengths of the coppers as before. This operation might be repeated till the coppers ceased to contract in length. In order to determine the pressures to which the coppers had been subjected, I would submit them to actual pressures, beginning with something below what their lengths seemed to indicate, and then test their lengths. If they did not contract, I would go on augmenting the pressure by equal increments till the copper plugs began to shew signs of further compression. In this way very near approximations to the *maximum* pressures in the bore of the gun would probably be obtained. Afterwards the same coppers might be used in the same plugs in experiments with a mixture of a small quantity of more rapidly exploding powder, or with charges altogether more violent. When a crusher gauge is inserted in the base of a shot care should be taken to arrange it so that the piston would not strike a blow on the copper cylinder when the shot was brought suddenly to rest.

147. As a matter of course the velocity of the shot should be measured near the gun by some perfectly trustworthy instrument. The Boulengé Chronoscope appears to be found convenient in use, and when in good working order, it gives satisfactory results. For during the progress of our recent experiments the velocities of the shot were measured by the

Boulengé instrument. For three comparisons in rounds 469, 470 and 472 the differences of the velocities given by the two instruments were 0, 0, and +1. But in round 468 two comparisons were obtained with differences +28 and −61 *f.s.* I am disposed to think that the working of the Boulengé chronoscope would be made more uniform (1) if some kind of a galvanometer was used, (2) in conjunction with the form of screen shewn in fig. 20, which would secure galvanic circuits of constant resistance. (Final Report, p. 8).

148. Of late, guns of large calibre have been provided with a powder chamber of greater radius (R) than that of the bore of the gun (r). It is evident that, for a given charge and shot, this arrangement would give the shot a longer portion of the bore to be propelled through, and that the powder, being formed into a thicker and shorter cylinder, would explode more rapidly. The consequences to be expected would be an increased muzzle velocity and a greater strain on the gun, even supposing that the gaseous pressure p, denoted by the crusher gauge, was the same in a chambered and in an unchambered gun. For the ratio of the pressure of the gas tending to burst the powder chamber to that tending to burst the bore of the gun would be as $R : r$. In a gun of uniform bore there is little longitudinal tension on the steel tube except that due to rifling and the friction of the shot which is but trifling. But when a gun is chambered the longitudinal tension on the sides of the powder chamber becomes $\pi (R^2 - r^2) p$, *in addition* to that which existed in the unchambered gun. And the scooping out of the powder chamber causes a great *variation of thickness* in the steel just at that point where the forces acting upon it are likely to vary so much.

149. It has been stated that the Italian 100-ton gun failed because "the steel tube parted at the base of the conical portion connecting the powder chamber with the bore," which is just the place where the gun might have been expected to fail, if it failed at all. In this case $R = 9{\cdot}85$ and $r = 8{\cdot}86$ inches. So that the ratio of the force tending to burst the powder chamber to that tending to burst the bore would be as 9·85 : 8·86, supposing the gaseous pressure p to be the same in both places. And the increased longitudinal tension on the powder chamber, entirely due to chambering would be $\pi (R^2 - r^2) p = 58{\cdot}2p = 1164$ tons, if $p = 20$ tons per square inch, and so on in proportion to p. This is quite

sufficient to explain the tearing asunder of the coils. The chamber is reported to have been extended as if by an extraordinary pressure.

150. In consequence of recent improvements in the manufacture of steel shot, Krupp has succeeded in firing an ogival-headed shot through 20 inches of iron plates, the shot preserving its form, and retaining sufficient velocity to carry it 2000 metres beyond the iron plates. It therefore appears, that now experiments might be undertaken with some prospect of success, to determine the laws which govern the perforation of iron plates by steel shot with any given form of head, provided only the velocity of the shot could be measured satisfactorily just before and just after impact. If the material of the shot and of the iron plates could be considered uniform, there would remain as variables the weight, diameter, and velocity of the shot, and the thickness of the iron plates. Experiments on a small scale could be made to yield valuable results.

151. The investigations of Trajectories, &c., contained in this work, suppose that the shot moves in the vertical plane passing through the direction of projection, and therefore they apply strictly only to the motion of spherical shot. One effect of the resistance of the air on rotating elongated projectiles is to draw them slightly from the vertical plane of projection as explained already (73), and also to affect, in some measure, their ranges, &c. I must refer the reader for information on these points to Saint-Robert, *Mémoires Scientifiques. Balistique*, p. 173; to Mayevski, *Traité de Balistique*, p. 154; and to several papers by Professor Greenhill in the *Proceedings of the Royal Artillery Institution*, Woolwich, vol. X, p. 577, and vol. XI, pp. 119, 124, and 131.

ERRATA.

Page 102, seventh line from bottom, *for* "K_n" *read* K_v, and page 122, eleventh line, *for* "were" *read* where. Also in Table (J), opposite velocity 1031 *f.s*, *for* "2238" *read* 2538; and opposite velocity 2016 *f.s*, *for* "4546" *read* 5546. Also in Final Report, p. 59, opposite velocity 505 *f's*, *for* "3·6608 *read* 3·6408.

March, 1881.

(A) VALUES OF X Y & T.

γ = 5.1

φ	X	Y	T
3.6°	.13106	.005395	.08719
3.5	.11783	.004577	.08239
3.4	.10805	.003987	.07825
3.3	.10008	.003520	.07452
3.2	.09325	.003132	.07106
3.1	.08723	.002801	.06781
3.0	.08181	.002512	.06473
2.9	.07687	.002258	.06179
2.8	.07231	.002030	.05896
2.7	.06806	.001826	.05624
2.6	.06408	.001642	.05360
2.5	.06033	.001475	.05104
2.4	.05677	.001323	.04855
2.3	.05339	.001184	.04611
2.2	.05016	.001057	.04374

γ = 5.2

φ	X	Y	T
3.6°	.14255	.006067	.08961
3.5	.12385	.004906	.08392
3.4	.11208	.004195	.07939
3.3	.10304	.003666	.07541
3.2	.09554	.003239	.07179
3.1	.08905	.002882	.06842
3.0	.08329	.002576	.06524
2.9	.07809	.002307	.06223
2.8	.07332	.002070	.05934
2.7	.06892	.001858	.05656
2.6	.06480	.001668	.05388
2.5	.06094	.001496	.05128
2.4	.05729	.001339	.04875
2.3	.05383	.001197	.04630
2.2	.05054	.001068	.04390
2.0	.04438	.000842	.03926
1.8	.03869	.000653	.03480
1.6	.03340	.000496	.03050
1.4	.02844	.000366	.02634
1.2	.02376	.000260	.02229
1.0	.01934	.000175	.01836
0.8	.01512	.000108	.01453
0.6	.01110	.000059	.01078
0.4	.00725	.000026	.00712
+.2	.00356	.000006	.00352
.0	.00000	.000000	.00000
—.2	.00343	.000006	.00346
0.4°	.00674	.000023	.00686
0.6	.00995	.000051	.01021
0.8	.01306	.000089	.01350
1	.01607	.000137	.01675
2	.03000	.000499	.03234
3	.04238	.001037	.04705
4	.05359	.001722	.06107
5	.06389	.002531	.07451
6	.07344	.003449	.08748
7	.08237	.004466	.10005
8	.09079	.005574	.11228
9	.09876	.006765	.12420
10	.10635	.008035	.13587
11	.11361	.009380	.14732
12	.12057	.010796	.15857
13	.12728	.012282	.16965
14	.13375	.013836	.18058
15	.14002	.015456	.19138
16	.14610	.017142	.20207
17	.15201	.018893	.21267
18	.17777	.020708	.22318
19	.16339	.022589	.23362
20	.16889	.024536	.24402
21	.17427	.026548	.25436
22	.17955	.028628	.26468
23	.18474	.030776	.27498
24	.18984	.032993	.28527
25	.19486	.035281	.29555
26	.19981	.037642	.30585
27	.20469	.040078	.31617
28	.20952	.042590	.32652
29	.21429	.045182	.33690
30	.21902	.047855	.34734
31	.22370	.050613	.35783
32	.22835	.053459	.36839
33	.23295	.056395	.37902
34	.23753	.059426	.38974
35	.24209	.062556	.40056
36	.24662	.065787	.41148
37	.25113	.069125	.42252
38	.25562	.072575	.43368
39	.26011	.076141	.44499
40	.26458	.079829	.45644
41	.26905	.083645	.46805
42	.27351	.087595	.47984
43	.27798	.091684	.49181
44	.28245	.095922	.50398
45	.28692	.100315	.51636

$\gamma = 5.3$

φ	X	Y	T
3.4°	.11705	.004456	.08071
3.3	.10647	.003836	.07641
3.2	.09810	.003360	.07258
3.1	.09105	.002972	.06907
3.0	.08489	.002644	.06578
2.9	.07939	.002361	.06268
2.8	.07440	.002112	.05973
2.7	.06982	.001892	.05690
2.6	.06556	.001695	.05417
2.5	.06158	.001517	.05153
2.4	.05784	.001357	.04897
2.3	.05429	.001212	.04648
2.2	.05093	.001079	.04406
2.1	.04773	.000959	.04169
2.0	.04466	.000849	.03938
1.9	.04172	.000749	.03711

$\gamma = 5.4$

φ	X	Y	T
3.4°	.12361	.004806	.08231
3.3	.11060	.004044	.07754
3.2	.10104	.003501	.07345
3.1	.09327	.003073	.06977
3.0	.08664	.002719	.06636
2.9	.08080	.002418	.06317
2.8	.07555	.002157	.06014
2.7	.07077	.001927	.05724
2.6	.06635	.001723	.05446
2.5	.06225	.001540	.05178
2.4	.05840	.001375	.04919
2.3	.05477	.001226	.04667
2.2	.05134	.001091	.04422
2.0	.04495	.000857	.03950
1.8	.03911	.000663	.03497
1.6	.03369	.000502	.03063
1.4	.02864	.000370	.02643
1.2	.02390	.000262	.02236
1.0	.01942	.000176	.01840
0.8	.01517	.000109	.01455
0.6	.01113	.000060	.01079
0.4	.00726	.000026	.00712
+.2	.00356	.000006	.00353
.0	.00000	.000000	.00000
−.2	.00343	.000006	.00346

$\gamma = 5.4$

φ	X	Y	T
0.4°	.00673	.000023	.00686
0.6	.00993	.000051	.01020
0.8	.01303	.000089	.01348
1	.01603	.000136	.01672
2	.02984	.000495	.03226
3	.04210	.001028	.04689
4	.05317	.001704	.06082
5	.06333	.002502	.07417
6	.07273	.003407	.08704
7	.08153	.004408	.09951
8	.08980	.005496	.11163
9	.09763	.006667	.12346
10	.10509	.007913	.13502
11	.11221	.009233	.14636
12	.11904	.010623	.15750
13	.12562	.012080	.16847
14	.13196	.013602	.17929
15	.13810	.015190	.18999
16	.14406	.016841	.20057
17	.14985	.018556	.21105
18	.15548	.020334	.22145
19	.16099	.022175	.23179
20	.16637	.024080	.24207
21	.17164	.026050	.25231
22	.17680	.028084	.26251
23	.18188	.030185	.27269
24	.18686	.032354	.28287
25	.19177	.034592	.29304
26	.19661	.036901	.30323
27	.20139	.039282	.31343
28	.20611	.041738	.32366
29	.21077	.044271	.33393
30	.21539	.046884	.34424
31	.21997	.049580	.35461
32	.22451	.052360	.36505
33	.22901	.055230	.37556
34	.23348	.058191	.38616
35	.23793	.061248	.39685
36	.24236	.064405	.40765
37	.24676	.067666	.41856
38	.25115	.071035	.42959
39	.25553	.074518	.44076
40	.25990	.078120	.45208
41	.26426	.081846	.46355
42	.26862	.085703	.47520
43	.27298	.089696	.48703
44	.27734	.093833	.49905
45	.28170	.098122	.51129

$\gamma = 5.5$

φ	X	Y	T
3.3°	.11576	.004308	.07887
3.2	.10447	.003666	.07443
3.1	.09577	.003187	.07053
3.0	.08856	.002803	.06698
2.9	.08232	.002481	.06367
2.8	.07678	.002205	.06056
2.7	.07177	.001965	.05760
2.6	.06719	.001753	.05477
2.5	.06294	.001563	.05205
2.4	.05898	.001394	.04941
2.3	.05527	.001241	.04686
2.2	.05175	.001103	.04439
2.1	.04842	.000978	.04197
2.0	.04525	.000865	.03962
1.9	.04222	.000762	.03732

$\gamma = 5.6$

φ	X	Y	T
3.3°	.12276	.004673	.08051
3.2	.10860	.003869	.07555
3.1	.09863	.003320	.07137
3.0	.09069	.002896	.06765
2.9	.08397	.002550	.06422
2.8	.07810	.002258	.06101
2.7	.07285	.002005	.05798
2.6	.06807	.001784	.05509
2.5	.06367	.001588	.05232
2.4	.05959	.001414	.04965
2.3	.05578	.001257	.04706
2.2	.05218	.001116	.04456
2.1	.04879	.000988	.04212
2.0	.04556	.000873	.03975
1.9	.04248	.000768	.03743
1.8	.03953	.000673	.03516
1.7	.03671	.000586	.03294
1.6	.03399	.000508	.03076
1.4	.02885	.000373	.02652
1.2	.02404	.000264	.02242
1.0	.01951	.000177	.01844
0.8	.01522	.000110	.01458
0.6	.01115	.000060	.01081
0.4	.00727	.000026	.00713
+.2	.00356	.000006	.00353
0	.00000	.000000	.00000
—.2	.00343	.000006	.00346

$\gamma = 5.6$

φ	X	Y	T
0.4°	.00673	.000023	.00685
0.6	.00991	.000051	.01019
0.8	.01300	.000088	.01347
1	.01598	.000135	.01670
2	.02971	.000492	.03218
3	.04184	.001020	.04674
4	.05278	.001687	.06058
5	.06279	.002474	.07384
6	.07206	.003366	.08662
7	.08071	.004351	.09899
8	.08885	.005421	.11101
9	.09655	.006572	.12273
10	.10387	.007796	.13419
11	.11087	.009092	.14542
12	.11757	.010456	.15646
13	.12402	.011885	.16733
14	.13025	.013379	.17805
15	.13627	.014935	.18864
16	.14210	.016554	.19911
17	.14778	.018234	.20949
18	.15330	.019976	.21979
19	.15870	.021780	.23002
20	.16396	.023646	.24019
21	.16912	.025574	.25032
22	.17418	.027567	.26042
23	.17915	.029623	.27049
24	.18403	.031746	.28056
25	.18883	.033936	.29062
26	.19357	.036195	.30070
27	.19824	.038525	.31079
28	.20286	.040928	.32091
29	.20742	.043406	.33107
30	.21194	.045962	.34127
31	.21642	.048598	.35152
32	.22086	.051318	.36185
33	.22526	.054123	.37224
34	.22963	.057019	.38272
35	.23398	.060008	.39329
36	.23831	.063094	.40397
37	.24262	.066282	.41475
38	.24691	.069576	.42566
39	.25119	.072980	.43671
40	.25546	.076500	.44790
41	.25972	.080142	.45924
42	.26398	.083911	.47076
43	.26824	.087813	.48245
44	.27250	.091856	.49434
45	.27677	.096047	.50643

$\gamma = 5.7$			
φ	X	Y	T
3.2°	.11382	.004130	.07687
3.1	.10198	.003477	.07232
3.0	.09308	.003003	.06837
2,9	.08579	.002627	.06480
2,8	.07952	.002315	.06149
2.7	.07399	.002049	.05838
2,6	.06900	.001818	.05543
2.5	.06444	.001615	.05260
2,4	.06023	.001434	.04989
2.3	.05631	.001273	.04727
2,2	.05263	.001129	.04473
2,1	.04916	.000999	.04227
2,0	.04587	.000881	.03988
1,9	.04274	.000774	.03754

$\gamma = 5.8$			
φ	X	Y	T
3,2°	.12111	.004501	.07852
3.1	.10602	.003670	.07340
3,0	.09582	.003126	.06918
2,9	.08780	.002712	.06543
2,8	.08107	.002377	.06200
2.7	.07521	.002096	.05880
2,6	.06998	.001854	.05578
2.5	.06525	.001643	.05290
2.4	.06089	.001456	.05014
2.3	.05686	.001291	.04748
2.2	.05309	.001143	.04492
2,1	.04955	.001009	.04243
2.0	.04620	.000889	.04001
1.9	.04302	.000781	.03765
1.8	.03999	.000683	.03535
1.7	.03709	.000595	.03310
1,6	.03431	.000515	.03089
1.4	.02907	.000377	.02662
1.2	.02418	.000266	.02249
1,0	.01960	.000178	.01849
0,8	.01528	.000110	.01460
0,6	.01118	.000060	.01082
0.4	.00729	.000026	.00713
+.2	.00356	.000006	.00353
0	.00000	.000000	.00000
−.2	.00342	.000006	.00346

$\gamma = 5.8$			
φ	X	Y	T
0.4°	.00672	.000023	.00685
0,6	.00989	.000051	.01018
0.8	.01296	.000088	.01345
1	.01594	.000135	.01667
2	.02956	.000489	.03210
3	.04157	.001012	.04659
4	.05238	.001671	.06035
5	.06226	.002448	.07352
6	.07140	.003326	.08621
7	.07992	.004296	.09848
8	.08793	.005350	.11040
9	.09550	.006481	.12202
10	.10269	.007684	.13339
11	.10956	.008957	.14452
12	.11615	.010296	.15546
13	.11248	.011699	.16623
14	.12858	.013165	.17685
15	.13449	.014692	.18733
16	.14022	.016279	.19771
17	.14578	.017927	.20798
18	.15120	.019635	.21818
19	.15648	.021403	.22831
20	.16164	.023231	.23838
21	.16670	.025121	.24841
22	.17165	.027073	.25840
23	.17652	.029088	.26837
24	.18130	.031167	.27833
25	.18601	.033312	.28829
26	.19064	.035524	.29826
27	.19522	.037805	.30825
28	.19974	.040158	.31826
29	.20421	.042584	.32831
30	.20863	.045085	.33840
31	.21301	.047665	.34855
32	.21735	.050327	.35876
33	.22166	.053073	.36904
34	.22595	.055906	.37941
35	.23020	.058831	.38987
36	.23443	.061850	.40043
37	.23865	.064969	.41109
38	.24285	.068191	.42189
39	.24703	.071521	.43281
40	.25121	.074964	.44387
41	.25538	.078526	.45509
42	.25955	.082212	.46648
43	.26371	.086029	.47804
44	.26788	.089982	.48980
45	.27205	.094080	.50176

$\gamma = 5.9$

φ	X	Y	T
3.0°	.09901	.003272	.07007
2.9	.09005	.002809	.06611
2.8	.08275	.002446	.06254
2.7	.07652	.002146	.05924
2.6	.07103	.001892	.05614
2.5	.06609	.001672	.05320
2.4	.06159	.001479	.05040
2.3	.05744	.001308	.04770
2.2	.05357	.001156	.04510
2.1	.04995	.001020	.04259
2.0	.04653	.000898	.04014
1.9	.04329	.000788	.03776
1.8	.04022	.000688	.03545
1.7	.03728	.000599	.03318
1.6	.03447	.000518	.03096

$\gamma = 6.0$

φ	X	Y	T
3.0°	.10285	.003448	.07109
2.9	.09260	.002920	.06686
2.8	.08461	.002522	.06312
2.7	.07794	.002201	.05971
2.6	.07214	.001933	.05653
2.5	.06699	.001703	.05352
2.4	.06232	.001503	.05066
2.3	.05803	.001327	.04793
2.2	.05406	.001171	.04529
2.1	.05035	.001032	.04275
2.0	.04687	.000907	.04028
1.9	.04358	.000795	.03788
1.8	.04045	.000694	.03554
1.7	.03748	.000603	.03326
1.6	.03463	.000521	.03103
1.4	.02929	.000381	.02671
1.2	.02433	.000268	.02255
1.0	.01969	.000179	.01853
0.8	.01533	.000110	.01463
0.6	.01121	.000060	.01083
0.4	.00730	.000026	.00714
+.2	.00357	.000006	.00353
0	.00000	.000000	.00000
—.2	.00342	.000006	.00346
0.4	.00671	.000023	.00684
0.6	.00988	.000051	.01017
0.8	.01294	.000088	.01344

$\gamma = 6.0$

φ	X	Y	T
1.0°	.01589	.000134	.01665
1.2	.01876	.000189	.01981
1.4	.02154	.000252	.02292
1.6	.02424	.000323	.02599
2	.02942	.000486	.03202
3	.04132	.001003	.04644
4	.05200	.001655	.06012
5	.06175	.002422	.07321
6	.07076	.003288	.08580
7	.07915	.004243	.09798
8	.08703	.005280	.10981
9	.09448	.006393	.12134
10	.10156	.007576	.13261
11	.10831	.008827	.14365
12	.11478	.010142	.15449
13	.12099	.011520	.16516
14	.12699	.012959	.17568
15	.13278	.014458	.18607
16	.13840	.016016	.19634
17	.14386	.017633	.20652
18	.14918	.019308	.21662
19	.15436	.021042	.22665
20	.15942	.022835	.23662
21	.16438	.024687	.24655
22	.16924	.026601	.25645
23	.17400	.028576	.26632
24	.17869	.030613	.27618
25	.18330	.032715	.28604
26	.18785	.034883	.29591
27	.19233	.037118	.30579
28	.19676	.039422	.31570
29	.20113	.041799	.32565
30	.20546	.044249	.33565
31	.20975	.046776	.34568
32	.21401	.049383	.35579
33	.21823	.052072	.36596
34	.22242	.054846	.37622
35	.22658	.057710	.38657
36	.23073	.060666	.39701
37	.23486	.063719	.40757
38	.23897	.066873	.41825
39	.24307	.070133	.42905
40	.24716	.073503	.44000
41	.25124	.076990	.45110
42	.25531	.080597	.46236
43	.25939	.084332	.47380
44	.26347	.088201	.48543
45	.26755	.092211	.49726

$\gamma = 6.1$

φ	X	Y	T
3.0°	.10774	.003678	.07227
2.9	.09556	.003050	.06769
2.8	.08668	.002607	.06375
2.7	.07948	.002261	.06021
2.6	.07334	.001977	.05693
2.5	.06793	.001736	.05385
2.4	.06308	.001528	.05094
2.3	.05865	.001346	.04816
2.2	.05457	.001186	.04549
2.1	.05077	.001044	.04291
2.0	.04722	.000916	.04042
1.9	.04387	.000802	.03800
1.8	.04069	.000699	.03564
1.7	.03768	.000607	.03335
1.6	.03480	.000524	.03110

$\gamma = 6.2$

φ	X	Y	T
2.9°	.09911	.003208	.06864
2.8	.08901	.002705	.06444
2.7	.08117	.002328	.06074
2.6	.07462	.002025	.05735
2.5	.06893	.001771	.05420
2.4	.06388	.001555	.05123
2.3	.05930	.001367	.04840
2.2	.05510	.001202	.04569
2.1	.05121	.001056	.04308
2.0	.04758	.000926	.04056
1.9	.04416	.000810	.03812
1.8	.04094	.000705	.03574
1.7	.03788	.000612	.03343
1.6	.03497	.000528	.03118
1.4	.02951	.000385	.02681
1.2	.02447	.000270	.02262
1.0	.01978	.000180	.01857
0.8	.01538	.000111	.01465
0.6	.01124	.000060	.01085
0.4	.00731	.000026	.00714
+.2	.00357	.000006	.00353
0	.00000	.000000	.00000
—.2	.00342	.000006	.00345
0.4	.00670	.000023	.00684
0.6	.00986	.000051	.01016
0.8	.01290	.000088	.01342
1.0°	.01585	.000134	.01663
1.2	.01870	.000189	.01978
1.4	.02146	.000252	.02288
1.6	.02414	.000322	.02594
2	.02928	.000483	.03194
3	.04106	.000995	.04629
4	.05163	.001640	.05990
5	.06125	.002396	.07290
6	.07014	.003251	.08540
7	.07840	.004192	.09750
8	.08616	.005213	.10923
9	.09349	.006308	.12067
10	.10045	.007472	.13184
11	.10709	.008702	.14279
12	.11345	.009995	.15354
13	.11956	.011349	.16411
14	.12545	.012762	.17454
15	.13114	.014234	.18484
16	.13666	.015764	.19502
17	.14202	.017351	.20510
18	.14723	.018995	.21511
19	.15232	.020696	.22504
20	.15728	.022456	.23492
21	.16215	.024273	.24476
22	.16691	.026150	.25456
23	.17159	.028087	.26434
24	.17618	.030085	.27410
25	.18071	.032146	.28386
26	.18516	.034271	.29363
27	.18956	.036462	.30342
28	.19390	.038721	.31323
29	.19819	.041051	.32308
30	.20243	.043452	.33297
31	.20663	.045929	.34291
32	.21080	.048483	.35291
33	.21494	.051117	.36299
34	.21905	.053836	.37314
35	.23313	.056642	.38338
36	.22719	.059538	.39372
37	.23123	.062529	.40417
38	.23526	.065618	.41474
39	.23927	.068811	.42543
40	.24328	.072113	.43627
41	.24728	.075527	.44725
42	.25127	.079060	.45840
43	.25526	.082718	.46972
44	.25926	.086507	.48123
45	.26325	.090433	.49294

$\gamma = 6.3$

φ	X	Y	T
2.9°	.10358	.003412	.06975
2.8	.09171	.002820	.06520
2.7	.08304	.002403	.06131
2.6	.07601	.002077	.05780
2.5	.07001	.001810	.05457
2.4	.06473	.001583	.05153
2.3	.05998	.001389	.04865
2.2	.05565	.001219	.04589
2.1	.05166	.001069	.04325
2.0	.04795	.000936	.04071
1.9	.04447	.000817	.03824
1.8	.04119	.000711	.03585
1.7	.03809	.000616	.03352
1.6	.03514	.000532	.03125

$\gamma = 6.4$

φ	X	Y	T
2.8°	.09490	.002957	.06606
2.7	.08515	.002488	.06193
2.6	.07753	.002135	.05828
2.5	.07116	.001851	.05495
2.4	.06563	.001614	.05184
2.3	.06070	.001411	.04890
2.2	.05623	.001236	.04611
2.1	.05213	.001082	.04343
2.0	.04834	.000946	.04086
1.9	.04479	.000825	.03837
1.8	.04145	.000717	.03595
1.7	.03831	.000621	.03361
1.6	.03532	.000535	.03132
1.4	.02974	.000389	.02691
1.2	.02463	.000273	.02268
1.0	.01988	.000181	.01861
0.8	.01544	.000112	.01468
0.6	.01127	.000061	.01086
0.4	.00732	.000026	.00715
+.2	.00357	.000006	.00353
.0	.00000	.000000	.00000
—.2	.00342	.000006	.00345
0.4	.00669	.000023	.00684
0.6	.00984	.000051	.01015
0.8	.01287	.000088	.01341
0.0	.01580	.000134	.01660
0.2	.01863	.000189	.01975
0.4	.02137	.000251	.02284

$\gamma = 6.4$

φ	X	Y	T
1.6°	.02404	.000320	.02589
1.8	.02663	.000396	.02890
2.0	.02915	.000480	.03187
2.2	.03160	.000570	.03480
2.4	.03398	.000666	.03769
3.0	.04082	.000987	.04615
4	.05126	.001625	.05967
5	.06077	.002372	.07259
6	.06953	.003214	.08502
7	.07768	.004142	.09702
8	.08532	.005148	.10867
9	.09254	.006226	.12002
10	.09939	.007371	.13110
11	.10592	.008581	.14196
12	.11217	.009852	.15262
13	.11817	.011183	.16310
14	.12396	.012572	.17344
15	.12955	.014018	.18364
16	.13497	.015521	.19374
17	.14023	.017080	.20373
18	.14535	.018694	.21364
19	.15035	.020365	.22349
20	.15523	.022092	.23327
21	.16000	.023876	.24302
22	.16467	.025717	.25272
23	.16926	.027618	.26241
24	.17377	.029579	.27209
25	.17821	.031600	.28176
26	.18258	.033685	.29143
27	.18689	.035835	.30113
28	.19115	.038050	.31084
29	.19536	.040335	.32059
30	.19952	.042690	.33039
31	.20364	.045118	.34023
32	.20773	.047623	.35014
33	.21178	.050206	.36011
34	.21581	.052871	.37016
35	.21981	.055622	.38031
36	.22379	.058461	.39054
37	.22775	.061392	.40089
38	.23170	.064421	.41135
39	.23564	.067551	.42194
40	.23956	.070786	.43267
41	.24348	.074132	.44354
42	.24739	.077595	.45458
43	.25130	.081179	.46579
44	.25521	.084892	.47718
45	.25913	.088740	.48877

$\gamma = 6.5$

φ	X	Y	T
2.8°	.09884	.003126	.06705
2.7	.08755	.002585	.06262
2.6	.07920	.002199	.05880
2.5	.07240	.001895	.05535
2.4	.06658	.001646	.05216
2.3	.06145	.001435	.04917
2.2	.05683	.001254	.04633
2.1	.05262	.001096	.04362
2.0	.04873	.000957	.04101
1.9	.04511	.000833	.03850
1.8	.04172	.000724	.03606
1.7	.03852	.000626	.03370
1.6	.03549	.000539	.03140

$\gamma = 6.6$

φ	X	Y	T
2.8°	.10393	.003344	.06825
2.7	.09033	.002700	.06338
2.6	.08105	.002270	.05936
2.5	.07373	.001944	.05578
2.4	.06759	.001681	.05251
2.3	.06223	.001461	.04945
2.2	.05746	.001273	.04656
2.1	.05312	.001110	.04380
2.0	.04914	.000968	.04117
1.9	.04544	.000842	.03863
1.8	.04199	.000730	.03617
1.7	.03875	.000631	.03379
1.6	.03568	.000543	.03147
1.4	.02998	.000393	.02702
1.2	.02478	.000275	.02275
1.0	.01997	.000183	.01866
0.8	.01549	.000112	.01470
0.6	.01129	.000061	.01087
0.4	.00733	.000026	.00715
+.2	.00357	.000006	.00353
0	.00000	.000000	.00000
—.2	.00341	.000006	.00345
0.4	.00668	.000023	.00683
0.6	.00982	.000050	.01014
0.8	.01285	.000087	.01339
1.0	.01576	.000133	.01658
1.2	.01858	.000187	.01972
1.4	.02130	.000249	.02280

$\gamma = 6.6$

φ	X	Y	T
1.6°	.02394	.000318	.02584
1.8	.02651	.000394	.02884
2.0	.02901	.000477	.03179
2.2	.03144	.000566	.03470
2.4	.03380	.000661	.03757
3.0	.04057	.000980	.04600
4	.05090	.001610	.05945
5	.06029	.002348	.07229
6	.06893	.003179	.08463
7	.07697	.004094	.09655
8	.08450	.005085	.10812
9	.09161	.006146	.11938
10	.09835	.007274	.13037
11	.10477	.008464	.14114
12	.11092	.009715	.15171
13	.11683	.011024	.16211
14	.12252	.012390	.17236
15	.12802	.013811	.18248
16	.13334	.015288	.19248
17	.13851	.016819	.20239
18	.14354	.018406	.21222
19	.14845	.020046	.22197
20	.15324	.021743	.23167
21	.15792	.023494	.24133
22	.16251	.025303	.35095
23	.16702	.027169	.26055
24	.17145	.029094	.27013
25	.17580	.031079	.27972
26	.18009	.033125	.28930
27	.18432	.035234	.29890
28	.18850	.037409	.30853
29	.19263	.039650	.31819
30	.19671	.041961	.32789
31	.20076	.044344	.33764
32	.20477	.046801	.34745
33	.20875	.049335	.35733
34	.21270	.051950	.36729
35	.21662	.054648	.37733
36	.22053	.057433	.38747
37	.22441	.060308	.39772
38	.22828	.063278	.40808
39	.23214	.066348	.41857
40	.23599	.069520	.42919
41	.23983	.072802	.43996
42	.24367	.076197	.45088
43	.24751	.079712	.46198
44	.25134	.083352	.47326
45	.25518	.087125	.48474

$\gamma = 6.7$

φ	X	Y	T
2.7°	.09365	.002839	.06425
2.6	.08313	.002351	.05997
2.5	.07519	.001997	.05624
2.4	.06867	.001718	.05287
2.3	.06307	.001488	.04974
2.2	.05811	.001293	.04679
2.1	.05365	.001125	.04400
2.0	.04956	.000979	.04133
1.9	.04579	.000850	.03876
1.8	.04227	.000737	.03628
1.7	.03897	.000636	.03388
1.6	.03586	.000546	.03155

$\gamma = 6.8$

φ	X	Y	T
2.7°	.09787	.003017	.06528
2.6	.08552	.002445	.06064
2.5	.07680	.002056	.05674
2.4	.06984	.001758	.05325
2.3	.06395	.001516	.05004
2.2	.05880	.001314	.04704
2.1	.05419	.001141	.04420
2.0	.05000	.000991	.04150
1.9	.04614	.000859	.03890
1.8	.04256	.000744	.03640
1.7	.03921	.000641	.03398
1.6	.03605	.000550	.03163
1.4	.03023	.000398	.02712
1.2	.02494	.000277	.02282
1.0	.02007	.000184	.01870
0.8	.01555	.000113	.01473
0.6	.01132	.000061	.01089
0.4	.00734	.000026	.00716
+.2	.00358	.000006	.00353
.0	.00000	.000000	.00000
—.2	.00341	.000006	.00345
0.4	.00667	.000023	.00683
0.6	.00980	.000050	.01013
0.8	.01281	.000087	.01337
1.0	.01571	.000132	.01656
1.2	.01851	.000186	.01969
1.4	.02122	.000248	.02277
1.6	.02385	.000317	.02580
1.8	.02640	.000392	.02878
2.0	.02888	.000474	.03171

$\gamma = 6.8$

φ	X	Y	T
2.2°	.03129	.000562	.03461
2.4	.03363	.000657	.03747
2.6	.03592	.000756	.04030
2.8	.03815	.000861	.04310
3.0	.04033	.000972	.04586
3.2	.04246	.001088	.04859
4	.05054	.001596	.05924
5	.05982	.002324	.07200
6	.06835	.003145	.08426
7	.07627	.004047	.09610
8	.08370	.005024	.10758
9	.09070	.006069	.11875
10	.09733	.007179	.12967
11	.10366	.008351	.14035
12	.10971	.009582	.15084
13	.11552	.010870	.16115
14	.12112	.012213	.17131
15	.12652	.013611	.18135
16	.13176	.015063	.19127
17	.13684	.016568	.20109
18	.14179	.018127	.21083
19	.14661	.019740	.22050
20	.15131	.021406	.23012
21	.15592	.023127	.23969
22	.16043	.024904	.24923
23	.16485	.026737	.25874
24	.16920	.028627	.26824
25	.17348	.030577	.27773
26	.17769	.032586	.28724
27	.18185	.034657	.29675
28	.18595	.036793	.30629
29	.19000	.038993	.31586
30	.19401	.041262	.32547
31	.19798	.043601	.33513
32	.20192	.046013	.34485
33	.20582	.048500	.35464
34	.20970	.051067	.36451
35	.21355	.053714	.37446
36	.21738	.056447	.38450
37	.22120	.059269	.39465
38	.22500	.062184	.40491
39	.22878	.065196	.41530
40	.23256	.068309	.42582
41	.23633	.071528	.43649
42	.24010	.074860	.44731
43	.24386	.078308	.45830
44	.24762	.081879	.46948
45	.25139	.085580	.48085

$\gamma = 6.9$

φ	X	Y	T
2.6°	.08832	.002557	.06138
2.5	.07858	.002123	.05727
2.4	.07110	.001802	.05365
2.3	.06489	.001547	.05036
2.2	.05952	.001336	.04730
2.1	.05476	.001157	.04441
2.0	.05045	.001003	.04167
1.9	.04650	.000869	.03904
1.8	.04285	.000750	.03651
1.7	.03944	.000646	.03407
1.6	.03624	.000554	.03171

$\gamma = 7.0$

φ	X	Y	T
2.6°	.09169	.002693	.06224
2.5	.08058	.002198	.05784
2.4	.07247	.001850	.05408
2.3	.06589	.001580	.05069
2.2	.06028	.001360	.04756
2.1	.05535	.001174	.04462
2.0	.05091	.001016	.04184
1.9	.04687	.000878	.03918
1.8	.04315	.000758	.03663
1.7	.03968	.000652	.03417
1.6	.03644	.000558	.03179
1.4	.03048	.000402	.02723
1.2	.02510	.000280	.02289
1.0	.02017	.000185	.01875
0.8	.01560	.000113	.01475
0.6	.01135	.000061	.01090
0.4	.00735	.000026	.00716
+.2	.00358	.000006	.00354
0	.00000	.000000	.00000
—.2	.00341	.000006	.00345
0.4	.00667	.000023	.00682
0.6	.00979	.000050	.01012
0.8	.01279	.000087	.01336
1.0	.01567	.000132	.01653
1.2	.01845	.000186	.01965
1.4	.02114	.000247	.02272
1.6	.02375	.000315	.02574
1.8	.02629	.000390	.02871
2.0	.02875	.000471	.03164

$\gamma = 7.0$

φ	X	Y	T
2.2°	.03114	.000559	.03453
2.4	.03347	.000653	.03738
2.6	.03574	.000752	.04019
2.8	.03795	.000856	.04297
3.0	.04010	.000965	.04572
3.2	.04221	.001079	.04844
4	.05020	.001581	.05903
5	.05937	.002301	.07171
6	.06779	.003111	.08389
7	.07561	.004001	.09565
8	.08293	.004964	.10705
9	.08983	.005995	.11814
10	.09637	.007089	.12898
11	.10260	.008243	.13958
12	.10855	.009454	.14998
13	.11427	.010722	.16022
14	.11978	.012044	.17030
15	.12510	.013419	.18025
16	.13025	.014847	.19009
17	.13525	.016328	.19983
18	.14011	.017860	.20949
19	.14485	.019446	.21908
20	.14948	.021084	.22862
21	.15400	.022776	.23811
22	.15844	.024522	.24756
23	.16279	.026324	.25699
24	.16706	.028181	.26641
25	.17126	.030097	.27582
26	.17540	.032071	.28524
27	.17949	.034106	.29467
28	.18352	.036203	.30412
29	.18750	.038365	.31361
30	.19144	.040594	.32314
31	.19534	.042891	.33271
32	.19920	.045260	.34234
33	.20304	.047702	.35204
34	.20684	.050222	.36182
35	.21063	.052822	.37168
36	.21439	.055506	.38163
37	.21813	.058277	.39169
38	.22186	.061138	.40186
39	.22558	.064095	.41215
40	.22929	.067151	.42258
41	.23299	.070312	.43315
42	.23669	.073582	.44387
43	.24038	.076967	.45476
44	.24407	.080473	.46583
45	.24777	.084105	.47709

$\gamma = 7.1$

φ	X	Y	T
2.5°	.08288	.002285	.05848
2.4	.07397	.001904	.05454
2.3	.06696	.001616	.05104
2.2	.06109	.001385	.04784
2.1	.05597	.001193	.04484
2.0	.05140	.001029	.04202
1.9	.04726	.000888	.03933
1.8	.04346	.000765	.03675
1.7	.03993	.000657	.03427
1.6	.03664	.000562	.03187
1.5	.03354	.000479	.02955
1.4	.03061	.000404	.02728
1.3	.02783	.000339	.02508

$\gamma = 7.2$

φ	X	Y	T
2.5°	.08558	.002389	.05920
2.4	.07565	.001963	.05503
2.3	.06813	.001655	.05141
2.2	.06194	.001412	.04812
2.1	.05662	.001212	.04507
2.0	.05191	.001043	.04220
1.9	.04766	.000898	.03948
1.8	.04378	.000773	.03688
1.7	.04019	.000663	.03437
1.6	.03685	.000567	.03195
1.4	.03075	.000407	.02734
1.2	.02527	.000282	.02297
1.0	.02027	.000186	.01879
0.8	.01566	.000114	.01478
0.6	.01138	.000061	.01091
0.4	.00737	.000026	.00717
+.2	.00358	.000006	.00354
0	.00000	.000000	.00000
—.2	.00341	.000006	.00345
0.4	.00666	.000023	.00682
0.6	.00977	.000050	.01011
0.8	.01276	.000086	.01334
1.0	.01563	.000132	.01651
1.2	.01840	.000185	.01962
1.4	.02107	.000246	.02267
1.6	.02366	.000314	.02568
1.8	.02618	.000388	.02865
2.0	.02862	.000469	.03157

$\gamma = 7.2$

φ	X	Y	T
2.2°	.03099	.000556	.03445
2.4	.03329	.000649	.03728
2.6	.03554	.000747	.04008
2.8	.03773	.000850	.04285
3.0	.03987	.000958	.04559
3.2	.04196	.001071	.04830
4	.04987	.001568	.05882
5	.05892	.002280	.07143
6	.06724	.003079	.08353
7	.07496	.003958	.09521
8	.08218	.004907	.10653
9	.08898	.005923	.11755
10	.09542	.007001	.12830
11	.10156	.008138	.13883
12	.10742	.009331	.14915
13	.11305	.010579	.15931
14	.11847	.011880	.16931
15	.12371	.013234	.17918
16	.12877	.014639	.18894
17	.13369	.016095	.19860
18	.13848	.017603	.20818
19	.14314	.019163	.21770
20	.14769	.020774	.22715
21	.15214	.022438	.23656
22	.15650	.024155	.24593
23	.16077	.025926	.25529
24	.16497	.027752	.26462
25	.16910	.029635	.27395
26	.17317	.031576	.28329
27	.17718	.033576	.29264
28	.18114	.035637	.30201
29	.18506	.037762	.31142
30	.18893	.039951	.32086
31	.19276	.042209	.33035
32	.19656	.044536	.33990
33	.20033	.046936	.34952
34	.20407	.049412	.35921
35	.20778	.051966	.36898
36	.21148	.054603	.37884
37	.21516	.057324	.38881
38	.21882	.060136	.39889
39	.22247	.063040	.40909
40	.22611	.066042	.41943
41	.22975	.069146	.42990
42	.23338	.072358	.44053
43	.23700	.075682	.45132
44	.24063	.079125	.46229
45	.24426	.082692	.47345

$\gamma = 7.3$

φ	X	Y	T
2.5°	.08886	.002518	.06001
2.4	.07752	.002031	.05557
2.3	.06939	.001697	.05180
2.2	.06285	.001440	.04843
2.1	.05730	.001232	.04531
2.0	.05244	.001058	.04240
1.9	.04808	.000909	.03964
1.8	.04411	.000781	.03700
1.7	.04045	.000669	.03448
1.6	.03705	.000571	.03204
1.5	.03387	.000485	.02968
1.4	.03088	.000409	.02740
1.3	.02804	.000342	.02517

$\gamma = 7.4$

φ	X	Y	T
2.5°	.09305	.002685	.06099
2.4	.07962	.002109	.05616
2.3	.07076	.001744	.05222
2.2	.06382	.001471	.04874
2.1	.05802	.001253	.04556
2.0	.05299	.001073	.04260
1.9	.04850	.000920	.03980
1.8	.04445	.000789	.03714
1.7	.04072	.000675	.03458
1.6	.03727	.000576	.03213
1.4	.03102	.000412	.02746
1.2	.02544	.000285	.02304
1.0	.02037	.000188	.01884
0.8	.01572	.000114	.01481
0.6	.01141	.000062	.01093
0.4	.00738	.000026	.00718
+.2	.00359	.000006	.00354
0	.00000	.000000	.00000
—.2	.00340	.000006	.00345
0.4	.00665	.000023	.00681
0.6	.00975	.000050	.01010
0.8	.01273	.000086	.01333
1.0	.01559	.000131	.01649
1.2	.01835	.000184	.01959
1.4	.02101	.000245	.02264
1.6	.02358	.000312	.02563
1.8	.02607	.000386	.02858
2.0	.02849	.000466	.03149
2.2°	.03084	.000552	.03436
2.4	.03312	.000644	.03719
2.6	.03535	.000741	.03998
2.8	.03752	.000844	.04273
3.0	.03964	.000951	.04545
3.2	.04171	.001063	.04814
4	.04954	.001554	.05862
5	.05849	.002258	.07116
6	.06670	.003048	.08318
7	.07432	.003914	.09479
8	.08144	.004851	.10603
9	.08815	.005853	.11697
10	.09450	.006915	.12765
11	.10054	.008035	.13810
12	.10632	.009211	.14834
13	.11187	.010440	.15842
14	.11721	.011721	.16835
15	.12236	.013054	.17814
16	.12735	.014437	.18783
17	.13219	.015871	.19741
18	.13690	.017355	.20692
19	.14148	.018889	.21635
20	.14596	.020475	.22573
21	.15034	.022111	.23506
22	.15463	.023800	.24436
23	.15883	.025542	.25363
24	.16296	.027338	.26289
25	.16703	.029190	.27215
26	.17103	.031098	.28140
27	.17497	.033065	.29068
28	.17886	.035092	.29997
29	.18271	.037180	.30930
30	.18652	.039333	.31866
31	.19028	.041552	.32807
32	.19402	.043840	.33754
33	.19772	.046200	.34707
34	.20140	.048633	.35668
35	.20505	.051144	.36637
36	.20868	.053735	.37615
37	.21230	.056409	.38603
38	.21590	.059172	.39602
39	.21949	.062026	.40613
40	.22308	.064976	.41637
41	.22664	.068027	.42676
42	.23020	.071183	.43729
43	.23377	.074449	.44799
44	.23733	.077832	.45886
45	.24090	.081336	.46993

γ = 7.5

φ	X	Y	T
2.4°	.08209	.002201	.05682
2.3	.07227	.001796	.05268
2.2	.06486	.001504	.04908
2.1	.05878	.001276	.04582
2.0	.05356	.001089	.04280
1.9	.04895	.000932	.03996
1.8	.04479	.000797	.03727
1.7	.04100	.000681	.03469
1.6	.03749	.000580	.03222
1.5	.03422	.000492	.02983
1.4	.03115	.000414	.02751
1.3	.02826	.000346	.02527

γ = 7.6

φ	X	Y	T
2.4°	.08513	.002313	.05758
2.3	.07396	.001854	.05316
2.2	.06598	.001540	.04943
2.1	.05959	.001300	.04609
2.0	.05416	.001106	.04301
1.9	.04941	.000944	.04013
1.8	.04515	.000806	.03740
1.7	.04128	.000688	.03480
1.6	.03771	.000585	.03231
1.4	.03129	.000417	.02757
1.2	.02561	.000288	.02312
1.0	.02048	.000189	.01888
0.8	.01578	.000115	.01484
0.6	.01144	.000062	.01094
0.4	.00739	.000026	.00718
+.2	.00359	.000006	.00354
0	.00000	.000000	.00000
—.2	.00340	.000006	.00345
0.4	.00664	.000023	.00681
0.6	.00973	.000050	.01010
0.8	.01270	.000086	.01331
1.0	.01555	.000131	.01647
1.2	.01829	.000184	.01957
1.4	.02093	.000244	.02261
1.6	.02349	.000311	.02560
1.8	.02597	.000384	.02854
2.0	.02837	.000463	.03143
2.2	.03070	.000549	.03429
2.4	.03296	.000640	.03710
2.6	.03517	.000736	.03987
2.8°	.03732	.000838	.04261
3.0	.03942	.000944	.04532
3.2	.04147	.001055	.04800
3.4	.04347	.001171	.05065
3.6	.04542	.001290	.05327
3.8	.04733	.001413	.05586
4	.04921	.001541	.05842
5	.05807	.002237	.07089
6	.06618	.003017	.08284
7	.07370	.003873	.09437
8	.08073	.004797	.10555
9	.08734	.005785	.11641
10	.09360	.006833	.12701
11	.09956	.007937	.13738
12	.10526	.009095	.14756
13	.11072	.010306	.15756
14	.11598	.011569	.16741
15	.12106	.012881	.17713
16	.12597	.014243	.18674
17	.13074	.015655	.19626
18	.13537	.017116	.20569
19	.13989	.018626	.21505
20	.14430	.020187	.22435
21	.14861	.021797	.23361
22	.15283	.023459	.24283
23	.15696	.025173	.25203
24	.16103	.026941	.26122
25	.16503	.028762	.27040
26	.16896	.030640	.27958
27	.17284	.032574	.28877
28	.17667	.034568	.29799
29	.18046	.036622	.30724
30	.18420	.038740	.31653
31	.18790	.040922	.32586
32	.19157	.043172	.33525
33	.19522	.045492	.34470
34	.19883	.047885	.35423
35	.20242	.050354	.36383
36	.20599	.052902	.37353
37	.20955	.055532	.38333
38	.21309	.058248	.39324
39	.21661	.061054	.40326
40	.22013	.063954	.41342
41	.22364	.066953	.42371
42	.22715	.070055	.43416
43	.23065	.073266	.44476
44	.23416	.076591	.45554
45	.23766	.080036	.46651

$\gamma = 7.7$

φ	X	Y	T
2.3°	.07587	.001921	.05369
2.2	.06720	.001580	.04981
2.1	.06044	.001326	.04637
2.0	.05479	.001124	.04323
1.9	.04989	.000956	.04030
1.8	.04552	.000815	.03754
1.7	.04157	.000694	.03491
1.6	.03794	.000590	.03240
1.5	.03458	.000499	.02997
1.4	.03144	.000419	.02763
1.3	.02849	.000350	.02536

$\gamma = 7.8$

φ	X	Y	T
2.3°	.07806	.001998	.05428
2.2	.06853	.001623	.05021
2.1	.06135	.001354	.04667
2.0	.05546	.001142	.04346
1.9	.05039	.000970	.04048
1.8	.04591	.000825	.03769
1.7	.04187	.000701	.03503
1.6	.03817	.000595	.03249
1.4	.03158	.000422	.02769
1.2	.02579	.000290	.02320
1.0	.02059	.000190	.01893
0.8	.01584	.000116	.01486
0.6	.01147	.000062	.01096
0.4	.00740	.000026	.00719
+.2	.00359	.000006	.00354
0	.00000	.000000	.00000
—.2	.00340	.000006	.00345
0.4	.00663	.000023	.00681
0.6	.00972	.000050	.01009
0.8	.01267	.000086	.01330
1.0	.01551	.000130	.01644
1.2	.01823	.000182	.01953
1.4	.02086	.000242	.02256
1.6	.02340	.000309	.02554
1.8	.02586	.000382	.02847
2.0	.02824	.000461	.03136
2.2	.03056	.000546	.03420
2.4	.03281	.000636	.03700
2.6	.03500	.000732	.03976
2.8°	.03713	.000832	.04249
3.0	.03920	.000937	.04519
3.2	.04123	.001047	.04785
3.4	.04321	.001161	.05048
3.6	.04515	.001280	.05309
3.8	.04705	.001402	.05567
4	.04890	.001528	.05823
5	.05765	.002216	.07062
6	.06567	.002987	.08251
7	.07309	.003832	.09396
8	.08003	.004745	.10506
9	.08656	.005720	.11585
10	.09273	.006753	.12638
11	.09861	.007842	.13668
12	.10423	.008984	.14678
13	.10961	.010177	.15671
14	.11479	.011421	.16649
15	.11979	.012714	.17614
16	.12463	.014056	.18568
17	.12933	.015446	.19512
18	.13389	.016885	.20448
19	.13834	.018372	.21376
20	.14268	.019909	.22300
21	.14692	.021495	.23218
22	.15108	.023131	.24133
23	.15515	.024818	.25046
24	.15915	.026558	.25957
25	.16308	.028351	.26868
26	.16696	.030198	.27779
27	.17078	.032101	.28691
28	.17454	.034064	.29605
29	.17827	.036086	.30523
30	.18195	.038169	.31444
31	.18559	.040316	.32370
32	.18921	.042530	.33301
33	.19279	.044812	.34238
34	.19635	.047166	.35183
35	.19988	.049595	.36136
36	.20339	.052101	.37098
37	.20689	.054688	.38070
38	.21037	.057359	.39052
39	.21384	.060119	.40047
40	.21730	.062972	.41054
41	.22075	.065921	.42075
42	.22420	.068972	.43111
43	.22765	.072130	.44163
44	.23109	.075400	.45232
45	.23454	.078788	.46320

$\gamma = 7.9$

φ	X	Y	T
2.2°	.07000	.001672	.05064
2.1	.06233	.001383	.04698
2.0	.05615	.001162	.04369
1.9	.05091	.000983	.04067
1.8	.04630	.000834	.03783
1.7	.04217	.000708	.03515
1.6	.03841	.000600	.03258
1.5	.03495	.000506	.03012
1.4	.03173	.000425	.02775
1.3	.02872	.000354	.02546

$\gamma = 8.0$

φ	X	Y	T
2.2°	.07165	.001726	.05110
2.1	.06338	.001416	.04731
2.0	.05689	.001183	.04394
1.9	.05145	.000998	.04086
1.8	.04671	.000845	.03798
1.7	.04249	.000715	.03526
1.6	.03866	.000605	.03268
1.4	.03188	.000427	.02781
1.2	.02597	.000293	.02327
1.0	.02069	.000191	.01898
0.8	.01590	.000116	.01489
0.6	.01150	.000062	.01097
0.4	.00741	.000026	.00719
+.2	.00359	.000006	.00354
0	.00000	.000000	.00000
−.2	.00340	.000006	.00344
0.4	.00662	.000023	.00680
0.6	.00970	.000050	.01008
0.8	.01264	.000085	.01328
1.0	.01546	.000130	.01642
1.2	.01817	.000182	.01950
1.4	.02078	.000242	.02252
1.6	.02330	.000308	.02549
1.8	.02575	.000380	.02841
2.0	.02812	.000458	.03129
2.2	.03041	.000542	.03412
2.4	.03264	.000632	.03691
2.6	.03481	.000727	.03966
2.8	.03692	.000826	.04238
3.0	.03898	.000930	.04507
3.2	.04099	.001039	.04772
3.4°	.04295	.001152	.05034
3.6	.04486	.001270	.05293
3.8	.04674	.001391	.05549
4.0	.04858	.001516	.05803
4.2	.05038	.001645	.06054
4.4	.05214	.001778	.06303
4.6	.05387	.001914	.06550
5	.05724	.002196	.07036
6	.06517	.002958	.08218
7	.07250	.003793	.09356
8	.07935	.004694	.10459
9	.08579	.005656	.11531
10	.09188	.006675	.12577
11	.09768	.007749	.13599
12	.10322	.008875	.14603
13	.10853	.010052	.15588
14	.11363	.011278	.16559
15	.11856	.012552	.17517
16	.12333	.013874	.18464
17	.12796	.015244	.19401
18	.13245	.016662	.20330
19	.13683	.018127	.21252
20	.14111	.019640	.22168
21	.14529	.021202	.23080
22	.14938	.022814	.23988
23	.15339	.024475	.24894
24	.15733	.026188	.25798
25	.16120	.027953	.26702
26	.16502	.029772	.27606
27	.16878	.031646	.28511
28	.17249	.033578	.29418
29	.17615	.035568	.30328
30	.17978	.037618	.31242
31	.18336	.039732	.32160
32	.18692	.041911	.33084
33	.19045	.044157	.34015
34	.19395	.046474	.34952
35	.19742	.048863	.35897
36	.20088	.051329	.36851
37	.20432	.053875	.37815
38	.20774	.056504	.38790
39	.21116	.059220	.39776
40	.21456	.062026	.40775
41	.21796	.064928	.41788
42	.22135	.067930	.42815
43	.22474	.071037	.43859
44	.22813	.074253	.44919
45	.23152	.077586	.45998

γ = 8,1			
φ	X	Y	T
2.2°	.07352	.001788	.05161
2.1	.06453	.001451	.04766
2.0	.05768	.001206	.04420
1.9	.05202	.001013	.04106
1.8	.04714	.000855	.03814
1.7	.04281	.000723	.03539
1.6	.03891	.000610	.03278
1.5	.03534	.000514	.03028
1.4	.03203	.000430	.02788
1.3	.02895	.000357	.02556

γ = 8,2			
φ	X	Y	T
2.2°	.07568	.001861	.05218
2.1	.06578	.001490	.04803
2.0	.05851	.001230	.04447
1.9	.05261	.001029	.04126
1.8	.04758	.000866	.03830
1.7	.04315	.000731	.03551
1.6	.03917	.000616	.03288
1.4	.03219	.000433	.02794
1.2	.02616	.000296	.02335
1.0	.02080	.000193	.01903
0.8	.01596	.000117	.01492
0.6	.01153	.000062	.01098
0.4	.00743	.000026	.00720
+.2	.00360	.000006	.00354
0	.00000	.000000	.00000
—.2	.00340	.000006	.00344
0.4	.00662	.000023	.00680
0.6	.00968	.000049	.01007
0.8	.01261	.000085	.01327
1.0	.01542	.000129	.01640
1.2	.01812	.000181	.01947
1.4	.02071	.000240	.02248
1.6	.02322	.000306	.02544
1.8	.02565	.000378	.02835
2.0	.02800	.000455	.03122
2.2	.03028	.000538	.03404
2.4	.03249	.000627	.03682
2.6	.03464	.000721	.03956
2.8	.03673	.000820	.04227
3.0	.03877	.000924	.04494
3.2	.04076	.001032	.04758
3.4°	.04270	.001144	.05019
3.6	.04460	.001260	.05277
3.8	.04646	.001380	.05532
4.0	.04828	.001503	.05784
4.2	.05006	.001630	.06034
4.4	.05180	.001761	.06281
4.6	.05351	.001896	.06526
5	.05684	.002176	.07010
6	.06467	.002930	.08185
7	.07192	.003754	.09317
8	.07868	.004644	.10413
9	.08504	.005594	.11478
10	.09106	.006600	.12517
11	.09677	.007659	.13532
12	.10224	.008770	.14529
13	.10747	.009930	.15508
14	.11251	.011139	.16472
15	.11737	.012396	.17423
16	.12207	.013699	.18363
17	.12663	.015049	.19294
18	.13106	.016446	.20216
19	.13537	.017890	.21131
20	.13958	.019381	.22040
21	.14370	.020920	.22945
22	.14773	.022507	.23847
23	.15168	.024144	.24745
24	.15556	.025831	.25643
25	.15937	.027570	.26540
26	.16313	.029361	.27437
27	.16683	.031207	.28335
28	.17048	.033109	.29235
29	.17409	.035068	.30138
30	.17766	.037088	.31045
31	.18120	.039169	.31956
32	.18470	.041314	.32873
33	.18817	.043525	.33796
34	.19162	.045806	.34726
35	.19504	.048159	.35664
36	.19844	.050586	.36611
37	.20183	.053092	.37567
38	.20520	.055680	.38534
39	.20856	.058353	.39512
40	.21191	.061116	.40504
41	.21525	.063972	.41508
42	.21859	.066927	.42528
43	.22193	.069984	.43563
44	.22527	.073150	.44615
45	.22860	.076431	.45685

$\gamma = 8.3$

φ	X	Y	T
2.1°	.06715	.001534	.04843
2.0	.05940	.001256	.04475
1.9	.05324	.001046	.04147
1.8	.04804	.000878	.03846
1.7	.04350	.000739	.03564
1.6	.03943	.000622	.03298
1.5	.03574	.000522	.03044
1.4	.03235	.000436	.02801
1.3	.02920	.000362	.02566

$\gamma = 8.4$

φ	X	Y	T
2.1°	.06869	.001583	.04886
2.0	.06036	.001284	.04505
1.9	.05390	.001064	.04169
1.8	.04852	.000890	.03863
1.7	.04385	.000748	.03577
1.6	.03971	.000628	.03308
1.4	.03251	.000439	.02807
1.2	.02635	.000299	.02343
1.0	.02092	.000194	.01908
0.8	.01602	.000117	.01495
0.6	.01156	.000063	.01100
0.4	.00744	.000027	.00720
+.2	.00360	.000006	.00354
0	.00000	.000000	.00000
—.2	.00339	.000006	.00344
0.4	.00661	.000023	.00679
0.6	.00967	.000049	.01006
0.8	.01259	.000085	.01325
1.0	.01538	.000129	.01638
1.2	.01807	.000180	.01944
1.4	.02065	.000239	.02244
1.6	.02314	.000305	.02539
1.8	.02555	.000376	.02829
2.0	.02788	.000453	.03115
2.2	.03014	.000536	.03396
2.4	.03233	.000624	.03673
2.6	.03446	.000717	.03946
2.8	.03654	.000815	.04215
3.0	.03856	.000917	.04481
3.2	.04053	.001024	.04744
3.4	.04245	.001135	.05004
3.6	.04433	.001250	.05260
3.8	.04617	.001369	.05514
4.0°	.04798	.001491	.05765
4.2	.04974	.001617	.06013
4.4	.05147	.001747	.06259
4.6	.05316	.001880	.06503
4.8	.05482	.002017	.06745
5.0	.05645	.002157	.06985
5.2	.05805	.002300	.07223
5.4	.05962	.002446	.07458
6.0	.06420	.002902	.08153
7	.07136	.003717	.09278
8	.07804	.004596	.10367
9	.08432	.005533	.11426
10	.09025	.006526	.12458
11	.09590	.007572	.13467
12	.10129	.008668	.14456
13	.10645	.009812	.15429
14	.11142	.011005	.16386
15	.11621	.012244	.17331
16	.12085	.013529	.18264
17	.12534	.014860	.19188
18	.12971	.016237	.20104
19	.13396	.017660	.21012
20	.13811	.019130	.21915
21	.14217	.020647	.22813
22	.14614	.022211	.23708
23	.15003	.023824	.24600
24	.15385	.025486	.25491
25	.15761	.027199	.26381
26	.16131	.028964	.27272
27	.16496	.030782	.28163
28	.16856	.032656	.29057
29	.17212	.034586	.29953
30	.17563	.036575	.30853
31	.17911	.038625	.31758
32	.18256	.040738	.32667
33	.18598	.042916	.33583
34	.18937	.045162	.34506
35	.19274	.047479	.35436
36	.19609	.049870	.36376
37	.19943	.052338	.37326
38	.20275	.054886	.38285
39	.20606	.057518	.39256
40	.20936	.060238	.40240
41	.21265	.063051	.41237
42	.21594	.065960	.42248
43	.21922	.068970	.43275
44	.22251	.072088	.44319
45	.22580	.075317	.45381

$\gamma = 8.5$			
φ	X	Y	T
2.1°	.07042	.001639	.04933
2.0	.06139	.001315	.04537
1.9	.05460	.001083	.04193
1.8	.04902	.000903	.03880
1.7	.04422	.000756	.03591
1.6	.03999	.000634	.03319
1.5	.03617	.000530	.03061
1.4	.03268	.000442	.02814
1.3	.02945	.000366	.02577

$\gamma = 8.6$			
φ	X	Y	T
2.1°	.07243	.001703	.04986
2.0	.06252	.001348	.04571
1.9	.05534	.001103	.04217
1.8	.04954	.000916	.03898
1.7	.04461	.000765	.03605
1.6	.04028	.000640	.03330
1.4	.03285	.000445	.02821
1.2	.02655	.000302	.02352
1.0	.02103	.000196	.01913
0.8	.01609	.000118	.01498
0.6	.01159	.000063	.01101
0.4	.00745	.000027	.00721
+.2	.00360	.000006	.00355
0	.00000	.000000	.00000
−.2	.00339	.000006	.00344
0.4	.00660	.000023	.00679
0.6	.00965	.000049	.01005
0.8	.01256	.000085	.01324
1.0	.01534	.000128	.01636
1.2	.01801	.000179	.01941
1.4	.02058	.000237	.02241
1.6	.02305	.000302	.02535
1.8	.02544	.000373	.02824
2.0	.02776	.000450	.03108
2.2	.03000	.000532	.03388
2.4	.03217	.000620	.03664
2.6	.03429	.000713	.03936
2.8	.03635	.000810	.04204
3.0	.03836	.000911	.04469
3.2	.04031	.001017	.04731
3.4	.04222	.001127	.04989
3.6	.04409	.001241	.05244
3.8	.04591	.001359	.05497

$\gamma = 8.6$			
φ	X	Y	T
4.0°	.04769	.001480	.05747
4.2	.04943	.001605	.05994
4.4	.05114	.001734	.06239
4.6	.05281	.001866	.06482
4.8	.05445	.002001	.06723
5.0	.05607	.002139	.06961
5.2	.05766	.002280	.07197
5.4	.05921	.002425	.07431
6.0	.06373	.002875	.08122
7	.07081	.003681	.09241
8	.07741	.004549	.10323
9	.08361	.005475	.11375
10	.08947	.006456	.12400
11	.09504	.007488	.13403
12	.10036	.008569	.14386
13	.10546	.009699	.15352
14	.11036	.010875	.16303
15	.11508	.012097	.17241
16	.11965	.013365	.18168
17	.12409	.014677	.19086
18	.12839	.016035	.19995
19	.13259	.017439	.20897
20	.13668	.018888	.21794
21	.14068	.020383	.22686
22	.14460	.021925	.23574
23	.14843	.023515	.24460
24	.15220	.025153	.25345
25	.15591	.026841	.26228
26	.15955	.028581	.27112
27	.16315	.030373	.27997
28	.16669	.032219	.28884
29	.17020	.034121	.29774
30	.17366	.036081	.30667
31	.17709	.038101	.31565
32	.18049	.040182	.32468
33	.18386	.042328	.33378
34	.18720	.044541	.34294
35	.19052	.046824	.35217
36	.19382	.049179	.36150
37	.19711	.051610	.37092
38	.20038	.054120	.38044
39	.20364	.056713	.39008
40	.20689	.059392	.39984
41	.21013	.062162	.40974
42	.21337	.065028	.41978
43	.21661	.067993	.42997
44	.21984	.071063	.44033
45	.22308	.074243	.45087

$\gamma = 8.7$

φ	X	Y	T
2.0°	.06375	.001385	.04607
1.9	.05612	.001125	.04242
1.8	.05009	.000930	.03917
1.7	.04500	.000774	.03619
1.6	.04057	.000647	.03341
1.5	.03661	.000539	.03078
1.4	.03302	.000448	.02828
1.3	.02972	.000370	.02587

$\gamma = 8.8$

φ	X	Y	T
2.0°	.06511	.001426	.04645
1.9	.05696	.001148	.04268
1.8	.05066	.000944	.03936
1.7	.04541	.000780	.03634
1.6	.04088	.000653	.03352
1.4	.03319	.000452	.02834
1.2	.02675	.000305	.02360
1.0	.02115	.000197	.01918
0.8	.01615	.000119	.01500
0.6	.01162	.000063	.01103
0.4	.00746	.000027	.00722
+2.	.00360	.000006	.00355
0	.00000	.000000	.00000
—.2	.00339	.000006	.00344
0.4	.00659	.000023	.00678
0.6	.00963	.000049	.01004
0.8	.01253	.000084	.01322
1.0	.01530	.000128	.01633
1.2	.01796	.000179	.01938
1.4	.02051	.000237	.02236
1.6	.02297	.000302	.02529
1.8	.02535	.000372	.02817
2.0	.02765	.000448	.03101
2.2	.02987	.000529	.03380
2.4	.03203	.000616	.03654
2.6	.03413	.000708	.03925
2.8	.03617	.000804	.04193
3.0	.03816	.000904	.04457
3.2	.04010	.001009	.04718
3.4	.04199	.001118	.04975
3.6	.04383	.001231	.05229
3.8	.04563	.001348	.05480
4.0°	.04740	.001468	.05729
4.2	.04912	.001592	.05975
4.4	.05081	.001719	.06219
4.6	.05247	.001849	.06460
4.8	.05410	.001983	.06699
5.0	.05570	.002120	.06936
5.2	.05727	.002260	.07171
5.4	.05881	.002403	.07404
6.0	.06327	.002848	.08091
7	.07027	.003645	.09203
8	.07679	.004503	.10279
9	.08292	.005418	.11325
10	.08871	.006386	.12344
11	.09421	.007405	.13340
12	.09946	.008473	.14317
13	.10449	.009587	.15277
14	.10932	.010748	.16222
15	.11399	.011954	.17153
16	.11850	.013205	.18074
17	.12287	.014500	.18985
18	.12712	.015839	.19888
19	.13126	.017223	.20784
20	.13529	.018652	.21675
21	.13924	.020127	.22560
22	.14310	.021647	.23443
23	.14688	.023215	.24322
24	.15060	.024830	.25201
25	.15425	.026495	.26078
26	.15784	.028210	.26956
27	.16139	.029976	.27834
28	.16488	.031796	.28715
29	.16834	.033671	.29598
30	.17175	.035603	.30485
31	.17513	.037593	.31377
32	.17848	.039645	.32273
33	.18180	.041760	.33176
34	.18509	.043941	.34085
35	.18836	.046190	.35002
36	.19162	.048511	.35928
37	.19486	.050907	.36863
38	.19808	.053380	.37809
39	.20129	.055935	.38765
40	.20449	.058575	.39734
41	.20769	.061305	.40716
42	.21088	.064128	.41713
43	.21407	.067050	.42725
44	.21726	.070074	.43753
45	.22045	.073208	.44799

$\gamma = 8.9$

φ	X	Y	T
2.0°	.06664	.001473	.04687
1.9	.05786	.001173	.04296
1.8	.05126	.000960	.03957
1.7	.04584	.000794	.03649
1.6	.04119	.000660	.03364
1.5	.03708	.000549	.03096
1.4	.03337	.000455	.02842
1.3	.02998	.000375	.02599

$\gamma = 9.0$

φ	X	Y	T
2.0°	.06838	.001526	.04733
1.9	.05883	.001200	.04326
1.8	.05189	.000976	.03978
1.7	.04629	.000805	.03665
1.6	.04151	.000667	.03376
1.4	.03355	.000458	.02849
1.2	.02696	.000308	.02369
1.0	.02127	.000199	.01923
0.8	.01622	.000119	.01503
0.6	.01165	.000063	.01104
0.4	.00747	.000027	.00722
+.2	.00361	.000006	.00355
0	.00000	.000000	.00000
—.2	.00339	.000006	.00344
0.4	.00658	.000023	.00678
0.6	.00962	.000049	.01003
0.8	.01250	.000084	.01321
1.0	.01526	.000128	.01631
1.2	.01790	.000178	.01935
1.4	.02044	.000236	.02233
1.6	.02289	.000300	.02525
1.8	.02525	.000370	.02812
2.0	.02753	.000446	.03095
2.2	.02974	.000527	.03373
2.4	.03188	.000613	.03647
2.6	.03396	.000704	.03916
2.8	.03599	.000799	.04182
3.0	.03796	.000899	.04444
3.2	.03988	.001003	.04703
3.4	.04175	.001111	.04959
3.6	.04358	.001223	.05212
3.8	.04537	.001338	.05463
4.0°	.04711	.001457	.05711
4.2	.04882	.001580	.05956
4.4	.05049	.001706	.06198
4.6	.05214	.001835	.06438
4.8	.05375	.001968	.06676
5.0	.05533	.002103	.06912
5.2	.05688	.002241	.07146
5.4	.05840	.002383	.07378
6.0	.06282	.002823	.08061
7	.06974	.003611	.09166
8	.07619	.004459	.10236
9	.08224	.005363	.11275
10	.08796	.006319	.12288
11	.09339	.007326	.13279
12	.09857	.008380	.14249
13	.10354	.009480	.15203
14	.10831	.010626	.16142
15	.11292	.011816	.17067
16	.11737	.013051	.17982
17	.12169	.014328	.18887
18	.12588	.015650	.19784
19	.12996	.017015	.20674
20	.13394	.018425	.21558
21	.13783	.019879	.22438
22	.14164	.021379	.23314
23	.14537	.022925	.24188
24	.14903	.024518	.25060
25	.15264	.026160	.25931
26	.15618	.027851	.26803
27	.15968	.029593	.27675
28	.16312	.031387	.28550
29	.16653	.033236	.29427
30	.16989	.035141	.30308
31	.17323	.037103	.31193
32	.17653	.039126	.32083
33	.17980	.041211	.32979
34	.18305	.043361	.33882
35	.18627	.045579	.34793
36	.18948	.047867	.35712
37	.19267	.050228	.36640
38	.19585	.052666	.37579
39	.19902	.055185	.38529
40	.20217	.057787	.39491
41	.20532	.060477	.40466
42	.20847	.063260	.41455
43	.21161	.066139	.42460
44	.21475	.069120	.43480
45	.21789	.072209	.44519

$\gamma = 9.1$

φ	X	Y	T
°			
1.9	.05989	.001230	.04357
1.8	.05257	.000994	.03999
1.7	.04675	.000816	.03681
1.6	.04185	.000675	.03388
1.5	.03757	.000558	.03115
1.4	.03374	.000462	.02856
1.3	.03026	.000380	.02610

$\gamma = 9.2$

φ	X	Y	T
°			
1.9	.06105	.001264	.04390
1.8	.05328	.001012	.04022
1.7	.04724	.000828	.03697
1.6	.04220	.000682	.03401
1.5	.03782	.000564	.03124
1.4	.03393	.000465	.02864
1.3	.03041	.000382	.02615
1.2	.02718	.000312	.02378
1.1	.02418	.000252	.02149
1.0	.02139	.000200	.01928
0.8	.01628	.000120	.01506
0.6	.01168	.000064	.01106
0.4	.00749	.000027	.00723
+.2	.00361	.000006	.00355
0	.00000	.000000	.00000
—.2	.00338	.000006	.00344
0.4	.00658	.000023	.00678
0.6	.00960	.000049	.01002
0.8	.01248	.000084	.01319
1.0	.01522	.000127	.01629
1.2	.01785	.000177	.01932
1.4	.02038	.000235	.02229
1.6	.02281	.000299	.02520
1.8	.02515	.000368	.02807
2.0	.02742	.000443	.03088
2.2	.02961	.000523	.03365
2.4	.03174	.000609	.03637
2.6	.03380	.000699	.03906
2.8	.03581	.000794	.04171
3.0	.03776	.000893	.04433
3.2	.03966	.000996	.04691
3.4	.04152	.001103	.04946
3.6	.04333	.001214	.05198
3.8	.04510	.001328	.05447
°			
4.0	.04683	.001446	.05693
4.2	.04852	.001567	.05937
4.4	.05018	.001692	.06178
4.6	.05180	.001820	.06417
4.8	.05340	.001951	.06653
5.0	.05497	.002085	.06888
5.2	.05651	.002222	.07121
5.4	.05802	.002362	.07351
6.0	.06238	.002798	.08031
7	.06922	.003577	.09131
8	.07560	.004415	.10194
9	.08158	.005308	.11227
10	.08723	.006254	.12234
11	.09259	.007248	.13219
12	.09771	.008289	.14183
13	.10262	.009376	.15131
14	.10733	.010507	.16064
15	.11188	.011682	.16983
16	.11627	.012900	.17892
17	.12053	.014161	.18791
18	.12466	.015466	.19682
19	.12869	.016813	.20566
20	.13262	.018204	.21445
21	.13646	.019639	.22318
22	.14021	.021119	.23189
23	.14390	.022644	.24056
24	.14751	.024216	.24923
25	.15106	.025835	.25788
26	.15456	.027503	.26654
27	.15801	.029221	.27520
28	.16141	.030991	.28389
29	.16476	.032815	.29260
30	.16808	.034693	.30135
31	.17137	.036629	.31014
32	.17463	.038624	.31898
33	.17785	.040680	.32787
34	.18106	.042800	.33684
35	.18424	.044987	.34588
36	.18740	.047243	.35501
37	.19055	.049571	.36423
38	.19368	.051975	.37355
39	.19680	.054458	.38298
40	.19991	.057024	.39253
41	.20302	.059676	.40221
42	.20612	.062420	.41204
43	.20922	.065259	.42201
44	.21232	.068198	.43215
45	.21541	.071242	.44246

$\gamma = 9.3$

φ	X	Y	T
1.9°	.06233	.001301	.04426
1.8	.05404	.001033	.04046
1.7	.04774	.000840	.03714
1.6	.04256	.000690	.03413
1.5	.03808	.000569	.03134
1.4	.03413	.000469	.02871
1.3	.03055	.000385	.02621

$\gamma = 9.4$

φ	X	Y	T
1.9°	.06377	.001343	.04465
1.8	.05485	.001054	.04071
1.7	.04828	.000853	.03732
1.6	.04293	.000699	.03427
1.5	.03835	.000575	.03144
1.4	.03433	.000473	.02879
1.3	.03070	.000388	.02627
1.2	.02740	.000315	.02387
1.1	.02435	.000254	.02156
1.0	.02151	.000202	.01934
0.8	.01635	.000121	.01509
0.6	.01172	.000064	.01107
0.4	.00750	.000027	.00723
+.2	.00361	.000006	.00355
0	.00000	.000000	.00000
—.2	.00338	.000006	.00344
0.4	.00657	.000022	.00677
0.6	.00958	.000049	.01002
0.8	.01245	.000084	.01318
1.0	.01519	.000127	.01627
1.2	.01781	.000177	.01929
1.4	.02032	.000234	.02225
1.6	.02273	.000297	.02515
1.8	.02506	.000366	.02801
2.0	.02731	.000441	.03082
2.2	.02949	.000520	.03358
2.4	.03160	.000605	.03629
2.6	.03364	.000695	.03897
2.8	.03563	.000789	.04161
3.0	.03757	.000887	.04421
3.2	.03946	.000989	.04678
3.4	.04130	.001095	.04932
3.6	.04309	.001205	.05183
3.8	.04484	.001318	.05431
4.0°	.04656	.001435	.05676
4.2	.04824	.001555	.05919
4.4	.04988	.001679	.06159
4.6	.05149	.001806	.06397
4.8	.05307	.001936	.06632
5.0	.05462	.002068	.06865
5.2	.05614	.002203	.07096
5.4	.05763	.002342	.07325
6.0	.06196	.002773	.08002
7	.06872	.003544	.09096
8	.07502	.004373	.10153
9	.08094	.005256	.11180
10	.08652	.006190	.12181
11	.09182	.007172	.13160
12	.09688	.008200	.14118
13	.10172	.009274	.15060
14	.10638	.010391	.15987
15	.11086	.011552	.16901
16	.11520	.012754	.17804
17	.11941	.014000	.18698
18	.12349	.015287	.19583
19	.12747	.016617	.20461
20	.13134	.017990	.21334
21	.13513	.019406	.22202
22	.13884	.020867	.23066
23	.14247	.022372	.23929
24	.14604	.023923	.24789
25	.14955	.025521	.25649
26	.15300	.027167	.26508
27	.15640	.028862	.27369
28	.15975	.030608	.28232
29	.16307	.032407	.29097
30	.16634	.034260	.29966
31	.16958	.036170	.30839
32	.17279	.038138	.31717
33	.17598	.040166	.32601
34	.17914	.042257	.33491
35	.18228	.044414	.34389
36	.18539	.046640	.35296
37	.18850	.048936	.36211
38	.19159	.051307	.37137
39	.19467	.053756	.38074
40	.19774	.056287	.39022
41	.20080	.058903	.39984
42	.20386	.061608	.40959
43	.20691	.064408	.41950
44	.20997	.067306	.42956
45	.21302	.070309	.43980

$\gamma = 9.5$

φ	X	Y	T
1°.9	.06541	.001391	.04508
1.8	.05573	.001078	.04097
1.7	.04884	.000867	.03751
1.6	.04331	.000707	.03440
1.5	.03863	.000581	.03154
1.4	.03453	.000477	.02887
1.3	.03085	.000390	.02633

$\gamma = 9.6$

φ	X	Y	T
1°.9	.06732	.001448	.04556
1.8	.05668	.001103	.04126
1.7	.04942	.000881	.03770
1.6	.04371	.000716	.03454
1.5	.03891	.000586	.03165
1.4	.03474	.000481	.02895
1.3	.03101	.000393	.02640
1.2	.02763	.000319	.02397
1.1	.02452	.000256	.02164
1.0	.02164	.000203	.01939
0.8	.01641	.000121	.01512
0.6	.01175	.000064	.01109
0.4	.00751	.000027	.00724
+.2	.00362	.000006	.00355
0	.00000	.000000	.00000
—.2	.00338	.000006	.00344
0.4	.00656	.000022	.00677
0.6	.00957	.000049	.01001
0.8	.01242	.000084	.01316
1.0	.01515	.000126	.01625
1.2	.01776	.000176	.01926
1.4	.02026	.000233	.02221
1.6	.02266	.000296	.02511
1.8	.02497	.000364	.02796
2.0	.02720	.000438	.03075
2.2	.02936	.000517	.03350
2.4	.03145	.000602	.03620
2.6	.03348	.000691	.03886
2.8	.03546	.000784	.04149
3.0	.03738	.000881	.04409
3.2	.03925	.000982	.04665
3.4	.04107	.001088	.04918
3.6	.04285	.001197	.05167
3.8	.04459	.001309	.05414
4°.0	.04629	.001424	.05658
4.2	.04795	.001543	.05899
4.4	.04958	.001666	.06138
4.6	.05117	.001792	.06375
4.8	.05273	.001920	.06610
5.0	.05427	.002051	.06842
5.2	.05577	.002185	.07072
5.4	.05725	.002322	.07300
6.0	.06153	.002749	.07973
7	.06823	.003511	.09061
8	.07446	.004331	.10113
9	.08031	.005204	.11134
10	.08582	.006128	.12129
11	.09106	.007098	.13101
12	.09606	.008115	.14054
13	.10085	.009175	.14990
14	.10544	.010279	.15912
15	.10988	.011425	.16820
16	.11416	.012613	.17717
17	.11831	.013842	.18605
18	.12234	.015113	.19485
19	.12627	.016427	.20358
20	.13010	.017782	.21225
21	.13384	.019180	.22087
22	.13750	.020622	.22946
23	.14108	.022107	.23803
24	.14460	.023638	.24658
25	.14806	.025215	.25512
26	.15147	.026840	.26366
27	.15483	.028513	.27221
28	.15814	.030236	.28078
29	.16140	.032011	.28938
30	.16464	.033840	.29801
31	.16784	.035724	.30668
32	.17100	.037666	.31540
33	.17415	.039667	.32418
34	.17726	.041731	.33303
35	.18036	.043859	.34195
36	.18344	.046054	.35095
37	.18650	.048320	.36004
38	.18955	.050659	.36924
39	.19258	.053075	.37854
40	.19561	.055571	.38796
41	.19863	.058152	.39751
42	.20165	.060821	.40720
43	.20467	.063583	.41704
44	.20768	.066442	.42703
45	.21069	.069403	.43720

$\gamma = 9.7$

φ	X	Y	T
1.8°	.05771	.001131	.04156
1.7	.05005	.000896	.03790
1.6	.04413	.000726	.03469
1.5	.03921	.000592	.03175
1.4	.03495	.000485	.02903
1.3	.03117	.000395	.02646
1.2	.02775	.000321	.02401
1.1	.02461	.000258	.02167
1.0	.02170	.000204	.01942

$\gamma = 9.8$

φ	X	Y	T
1.8°	.05885	.001161	.04187
1.7	.05071	.000913	.03811
1.6	.04457	.000735	.03483
1.5	.03952	.000599	.03186
1.4	.03517	.000489	.02911
1.3	.03133	.000398	.02652
1.2	.02787	.000322	.02406
1.1	.02470	.000259	.02171
1.0	.02177	.000205	.01945
0.8	.01649	.000122	.01515
0.6	.01178	.000064	.01110
0.4	.00752	.000027	.00725
+.2	.00362	.000006	.00355
0	.00000	.000000	.00000
—.2	.00338	.000006	.00343
0.4	.00655	.000022	.00676
0.6	.00955	.000049	.01000
0.8	.01240	.000083	.01315
1.0	.01511	.000126	.01623
1.2	.01770	.000176	.01924
1.4	.02018	.000233	.02218
1.6	.02257	.000295	.02506
1.8	.02487	.000363	.02790
2.0	.02710	.000436	.03069
2.2	.02925	.000514	.03343
2.4	.03132	.000598	.03612
2.6	.03333	.000687	.03877
2.8	.03529	.000779	.04139
3.0	.03720	.000875	.04398
3.2	.03906	.000975	.04653
3.4	.04087	.001079	.04905
3.6	.04263	.001187	.05153
3.8	.04435	.001299	.05399
4.0°	.04603	.001414	.05642
4.2	.04768	.001532	.05882
4.4	.04929	.001653	.06120
4.6	.05087	.001778	.06356
4.8	.05242	.001905	.06589
5.0	.05394	.002035	.06820
5.2	.05543	.002168	.07049
5.4	.05689	.002304	.07276
6.0	.06113	.002726	.07945
7	.06775	.003480	.09027
8	.07391	.004291	.10073
9	.07969	.005155	.11089
10	.08515	.006067	.12078
11	.09033	.007027	.13045
12	.09527	.008031	.13992
13	.10000	.009079	.14923
14	.10454	.010169	.15839
15	.10892	.011301	.16742
16	.11315	.012474	.17633
17	.11725	.013689	.18516
18	.12123	.014945	.19390
19	.12511	.016241	.20257
20	.12889	.017580	.21119
21	.13258	.018960	.21976
22	.13619	.020384	.22830
23	.13974	.021851	.23681
24	.14321	.023362	.24530
25	.14663	.024919	.25379
26	.14999	.026523	.26227
27	.15330	.028174	.27077
28	.15657	.029875	.27929
29	.15980	.031628	.28783
30	.16299	.033433	.29640
31	.16615	.035292	.30501
32	.16927	.037208	.31368
33	.17237	.039184	.32240
34	.17545	.041220	.33119
35	.17851	.043320	.34005
36	.18154	.045487	.34900
37	.18457	.047723	.35803
38	.18757	.050031	.36717
39	.19057	.052416	.37641
40	.19356	.054879	.38577
41	.19654	.057425	.39525
42	.19952	.060059	.40488
43	.20249	.062784	.41465
44	.20546	.065605	.42458
45	.20844	.068527	.43468

$\gamma = 9.9$

φ	X	Y	T
1.8°	.06011	.001196	.04221
1.7	.05141	.000930	.03833
1.6	.04502	.000746	.03499
1.5	.03983	.000605	.03197
1.4	.03540	.000493	.02919
1.3	.03150	.000401	.02658
1.2	.02799	.000324	.02411
1.1	.02479	.000260	.02175
1.0	.02184	.000206	.01948

$\gamma = 10.0$

φ	X	Y	T
1.8°	.06154	.001236	.04259
1.7	.05216	.000949	.03855
1.6	.04550	.000757	.03514
1.5	.04015	.000612	.03209
1.4	.03563	.000498	.02928
1.3	.03166	.000404	.02665
1.2	.02811	.000326	.02416
1.1	.02488	.000262	.02178
1.0	.02190	.000207	.01950
0.8	.01655	.000123	.01518
0.6	.01181	.000065	.01112
0.4	.00754	.000027	.00725
+.2	.00362	.000006	.00356
0	.00000	.000000	.00000
—.2	.00338	.000006	.00343
0.4	.00654	.000022	.00676
0.6	.00954	.000048	.00999
0.8	.01237	.000083	.01314
1.0	.01507	.000125	.01621
1.2	.01765	.000175	.01921
1.4	.02012	.000231	.02214
1.6	.02249	.000293	.02502
1.8	.02478	.000361	.02785
2.0	.02699	.000434	.03063
2.2	.02912	.000512	.03336
2.4	.03118	.000595	.03605
2.6	.03318	.000683	.03869
2.8	.03513	.000775	.04130
3.0	.03702	.000870	.04387
3.2	.03886	.000969	.04641
3.4	.04065	.001073	.04891
3.6	.04239	.001180	.05138
3.8	.04410	.001290	.05383
4.0°	.04577	.001404	.05625
4.2	.04740	.001521	.05864
4.4	.04900	.001641	.06101
4.6	.05057	.001764	.06335
4.8	.05210	.001890	.06567
5.0	.05360	.002019	.06797
5.2	.05508	.002151	.07025
5.4	.05652	.002285	.07251
6.0	.06072	.002703	.07917
7	.06728	.003450	.08994
8	.07337	.004252	.10034
9	.07909	.005106	.11044
10	.08449	.006008	.12028
11	.08961	.006957	.12990
12	.09449	.007950	.13932
13	.09916	.008985	.14857
14	.10365	.010063	.15767
15	.10798	.011181	.16664
16	.11216	.012341	.17551
17	.11621	.013541	.18428
18	.12015	.014781	.19297
19	.12398	.016062	.20159
20	.12771	.017384	.21015
21	.13136	.018748	.21867
22	.13493	.020153	.22715
23	.13842	.021602	.23561
24	.14186	.023095	.24405
25	.14523	.024632	.25248
26	.14855	.026215	.26092
27	.15182	.027846	.26936
28	.15505	.029526	.27782
29	.15823	.031256	.28630
30	.16138	.033038	.29482
31	.16450	.034874	.30338
32	.16759	.036766	.31199
33	.17065	.038716	.32066
34	.17369	.040726	.32939
35	.17671	.042800	.33820
36	.17970	.044938	.34708
37	.18269	.047146	.35606
38	.18566	.049424	.36513
39	.18862	.051778	.37432
40	.19157	.054209	.38361
41	.19451	.056722	.39304
42	.19745	.059322	.40260
43	.20038	.062011	.41231
44	.20332	.064796	.42217
45	.20625	.067680	.43021

$\gamma = 10.1$

φ	X	Y	T
1.7°	.05297	.000970	.03879
1.6	.04600	.000769	.03531
1.5	.04049	.000619	.03221
1.4	.03587	.000502	.02937
1.3	.03183	.000407	.02671

$\gamma = 10.2$

1.7°	.05384	.000992	.03905
1.6	.04652	.000781	.03548
1.5	.04083	.000627	.03233
1.4	.03611	.000507	.02946
1.3	.03201	.000410	.02678

$\gamma = 10.3$

1.7°	.05478	.001016	.03932
1.6	.04707	.000793	.03565
1.5	.04120	.000634	.03245
1.4	.03636	.000512	.02955
1.3	.03219	.000413	.02685

$\gamma = 10.4$

1.7°	.05582	.001043	.03961
1.6	.04765	.000807	.03584
1.5	.04157	.000642	.03258
1.4	.03661	.000517	.02964
1.3	.03237	.000416	.02692
1.2	.02862	.000335	.02436
1.1	.02526	.000267	.02194
1.0	.02218	.000211	.01962
0.8	.01670	.000124	.01524
0.6	.01188	.000065	.01115
0.4	.00756	.000027	.00726
+.2	.00363	.000006	.00356
0	.00000	.000000	.00000
—.2	.00337	.000006	.00343
0.4	.00653	.000022	.00675
0.6	.00950	.000048	.00997
0.8	.01232	.000083	.01311
1.0	.01500	.000125	.01617
1.2	.01755	.000175	.01915
1.4	.02000	.000231	.02207

$\gamma = 10.4$

φ	X	Y	T
1.6°	.02235	.000292	.02493
1.8	.02460	.000359	.02774
2.0	.02677	.000431	.03050
2.2	.02887	.000508	.03321
2.4	.03090	.000590	.03587
3.0	.03665	.000860	.04364
4	.04526	.001385	.05592
5	.05295	.001988	.06754
6	.05993	.002660	.07863
7	.06635	.003391	.08928
8	.07232	.004176	.09958
9	.07792	.005012	.10957
10	.08320	.005895	.11930
11	.08821	.006823	.12881
12	.09298	.007794	.13812
13	.09755	.008806	.14727
14	.10193	.009859	.15627
15	.10616	.010952	.16514
16	.11024	.012084	.17390
17	.11420	.013256	.18257
18	.11804	.014467	.19115
19	.12178	.015718	.19967
20	.12543	.017009	.20813
21	.12899	.018340	.21655
22	.13247	.019712	.22493
23	.13588	.021126	.23328
24	.13923	.022582	.24162
25	.14253	.024083	.24995
26	.14576	.025628	.25828
27	.14896	.027219	.26662
28	.15210	.028857	.27498
29	.15521	.030545	.28336
30	.15828	.032283	.29178
31	.16133	.034074	.30023
32	.16434	.035920	.30873
33	.16733	.037822	.31729
34	.17028	.039782	.32591
35	.17323	.041804	.33461
36	.17615	.043890	.34338
37	.17906	.046042	.35225
38	.18196	.048264	.36121
39	.18484	.050558	.37027
40	.18772	.052929	.37945
41	.19059	.055379	.38876
42	.19345	.057914	.39820
43	.19631	.060536	.40779
44	.19917	.063250	.41753
45	.20203	.066061	.42743

$\gamma = 10.5$

φ	X	Y	T
1.7°	.05697	.001072	.03992
1.6	.04826	.000821	.03603
1.5	.04196	.000650	.03271
1.4	.03688	.000522	.02974
1.3	.03255	.000420	.02699

$\gamma = 10.6$

φ	X	Y	T
1.7°	.05824	.001105	.04026
1.6	.04892	.000836	.03623
1.5	.04237	.000659	.03285
1.4	.03715	.000527	.02983
1.3	.03275	.000423	.02706

$\gamma = 10.7$

φ	X	Y	T
1.6°	.04962	.000853	.03644
1.5	.04279	.000668	.03299
1.4	.03744	.000532	.02993
1.3	.03294	.000426	.02714
1.2	.02903	.000341	.02452

$\gamma = 10.8$

φ	X	Y	T
1.6°	.05037	.000871	.03666
1.5	.04323	.000678	.03314
1.4	.03772	.000538	.03004
1.3	.03314	.000430	.02721
1.2	.02918	.000343	.02458
1.1	.02565	.000272	.02210
1.0	.02247	.000214	.01974
0.8	.01684	.000125	.01531
0.6	.01195	.000066	.01118
0.4	.00759	.000027	.00728
+.2	.00363	.000006	.00356
0	.00000	.000000	.00000
—.2	.00337	.000006	.00343
0.4	.00651	.000022	.00674
0.6	.00947	.000048	.00996
0.8	.01227	.000082	.01308
1.0	.01492	.000124	.01612
1.2	.01745	.000172	.01910
1.4	.01987	.000227	.02200

$\gamma = 10.8$

φ	X	Y	T
1.6°	.02219	.000288	.02485
1.8	.02442	.000354	.02764
2.0	.02657	.000425	.03038
2.2	.02864	.000501	.03307
2.4	.03065	.000582	.03572
3.0	.03631	.000848	.04343
4	.04477	.001365	.05560
5	.05232	.001957	.06711
6	.05917	.002616	.07809
7	.06547	.003333	.08864
8	.07132	.004103	.09884
9	.07680	.004921	.10873
10	.08197	.005786	.11835
11	.08687	.006694	.12776
12	.09154	.007643	.13697
13	.09601	.008634	.14601
14	.10030	.009663	.15491
15	.10443	.010732	.16369
16	.10842	.011839	.17235
17	.11229	.012985	.18092
18	.11604	.014168	.18941
19	.11970	.015391	.19783
20	.12326	.016652	.20619
21	.12674	.017952	.21451
22	.13014	.019293	.22280
23	.13348	.020674	.23105
24	.13675	.022096	.23929
25	.13996	.023561	.24753
26	.14313	.025070	.25576
27	.14624	.026624	.26400
28	.14932	.028224	.27226
29	.15235	.029872	.28054
30	.15535	.031569	.28885
31	.15832	.033318	.29720
32	.16126	.035119	.30560
33	.16417	.036975	.31406
34	.16707	.038889	.32258
35	.16994	.040863	.33117
36	.17279	.042899	.33984
37	.17563	.044999	.34859
38	.17846	.047168	.35745
39	.18127	.049407	.36640
40	.18408	.051720	.37547
41	.18688	.054112	.38467
42	.18967	.056584	.39399
43	.19246	.059143	.40346
44	.19525	.061792	.41308
45	.19805	.064535	.42287

$\gamma = 10.9$

φ	X	Y	T
1°.6	.05118	.000891	.03690
1.5	.04370	.000688	.03329
1.4	.03802	.000544	.03014
1.3	.03335	.000433	.02729
1.2	.02932	.000346	.02464

$\gamma = 11.0$

φ	X	Y	T
1°.6	.05207	.000912	.03715
1.5	.04419	.000698	.03345
1.4	.03834	.000550	.03025
1.3	.03356	.000437	.02736
1.2	.02947	.000348	.02469

$\gamma = 11.1$

φ	X	Y	T
1°.6	.05304	.000936	.03742
1.5	.04470	.000709	.03361
1.4	.03866	.000556	.03036
1.3	.03378	.000441	.02744
1.2	.02962	.000350	.02475

$\gamma = 11.2$

φ	X	Y	T
1°.6	.05410	.000962	.03770
1.5	.04524	.000721	.03378
1.4	.03899	.000563	.03048
1.3	.03400	.000445	.02752
1.2	.02977	.000353	.02481
1.1	.02608	.000279	.02227
1.0	.02277	.000218	.01987
0.8	.01700	.000127	.01538
0.6	.01202	.000066	.01121
0.4	.00761	.000027	.00729
+.2	.00364	.000006	.00356
0	.00000	.000000	.00000
—.2	.00336	.000006	.00343
0.4	.00650	.000022	.00673
0.6	.00944	.000048	.00994
0.8	.01222	.000082	.01305
1.0	.01485	.000123	.01608
1.2	.01736	.000171	.01904
1.4	.01975	.000225	.02193

$\gamma = 11.2$

φ	X	Y	T
1°.6	.02204	.000285	.02476
1.8	.02425	.000351	.02754
2.0	.02637	.000421	.03026
2.2	.02842	.000496	.03293
2.4	.03040	.000576	.03556
3.0	.03597	.000838	.04321
4	.04430	.001346	.05529
5	.05172	.001929	.06671
6	.05844	.002575	.07759
7	.06462	.003279	.08804
8	.07036	.004033	.09813
9	.07573	.004836	.10792
10	.08079	.005682	.11745
11	.08559	.006572	.12676
12	.09016	.007501	.13588
13	.09453	.008471	.14482
14	.09873	.009478	.15363
15	.10278	.010524	.16231
16	.10668	.011607	.17088
17	.11046	.012728	.17935
18	.11414	.013885	.18774
19	.11771	.015081	.19607
20	.12119	.016314	.20434
21	.12459	.017585	.21257
22	.12792	.018896	.22076
23	.13118	.020246	.22892
24	.13438	.021636	.23707
25	.13752	.023069	.24521
26	.14061	.024543	.25335
27	.14366	.026062	.26150
28	.14666	.027625	.26966
29	.14963	.029236	.27785
30	.15256	.030894	.28606
31	.15546	.032602	.29432
32	.15833	.034362	.30262
33	.16118	.036176	.31098
34	.16401	.038046	.31940
35	.16681	.039974	.32789
36	.16960	.041963	.33646
37	.17237	.044015	.34512
38	.17513	.046133	.35386
39	.17788	.048320	.36272
40	.18062	.050580	.37168
41	.18336	052915	.38077
42	.18609	.055331	.38998
43	.18882	.057829	.39934
44	.19154	.060416	.40885
45	.19427	.063095	.41852

$\gamma = 11.3$

φ	X	Y	T
1°.5	.04582	.000734	.03395
1.4	.03934	.000570	.03059
1.3	.03423	.000449	.02761
1.2	.02993	.000355	.02487
1.1	.02619	.000280	.02231

$\gamma = 11.4$

φ	X	Y	T
1°.5	.04643	.000748	.03414
1.4	.03970	.000576	.03071
1.3	.03446	.000454	.02769
1.2	.03009	.000358	.02493
1.1	.02630	.000282	.02236

$\gamma = 11.5$

φ	X	Y	T
1°.5	.04708	.000762	.03433
1.4	.04007	.000584	.03084
1.3	.03470	.000458	.02777
1.2	.03026	.000361	.02499
1.1	.02641	.000284	.02240

$\gamma = 11.6$

φ	X	Y	T
1°.5	.04778	.000778	.03453
1.4	.04046	.000593	.03096
1.3	.03495	.000462	.02786
1.2	.03042	.000364	.02505
1.1	.02653	.000285	.02244
1.0	.02309	.000222	.01999
0.8	.01715	.000129	.01544
0.6	.01209	.000067	.01124
0.4	.00764	.000028	.00730
+.2	.00364	.000007	.00357
0	.00000	.000000	.00000
—.2	.00336	.000006	.00342
0.4	.00648	.000022	.00673
0.6	.00941	.000048	.00992
0.8	.01217	.000081	.01303
1.0	.01478	.000122	.01605
1.2	.01726	.000170	.01899
1.4	.01963	.000224	.02187

$\gamma = 11.6$

φ	X	Y	T
1°.6	.02190	.000283	.02468
1.8	.02408	.000347	.02744
2.0	.02617	.000417	.03015
2.2	.02819	.000491	.03281
2.4	.03014	.000570	.03542
3.0	.03564	.000828	.04301
4	.04384	.001328	.05499
5	.05113	.001901	.06631
6	.05774	.002536	.07709
7	.06380	.003226	.08745
8	.06943	.003967	.09745
9	.07470	.004753	.10714
10	.07966	.005582	.11658
11	.08436	.006455	.12579
12	.08884	.007366	.13481
13	.09312	.008315	.14367
14	.09724	.009302	.15238
15	.10120	.010326	.16097
16	.10502	.011387	.16944
17	.10873	.012484	.17783
18	.11232	.013617	.18613
19	.11582	.014787	.19437
20	.11923	.015994	.20255
21	.12255	.017238	.21069
22	.12581	.018520	.21879
23	.12900	.019841	.22686
24	.13213	.021201	.23492
25	.13520	.022602	.24297
26	.13823	.024044	.25102
27	.14120	.025529	.25908
28	.14414	.027059	.26715
29	.14704	.028633	.27525
30	.14991	.030255	.28337
31	.15275	.031926	.29154
32	.15555	.033647	.29975
33	.15834	.035420	.30801
34	.16110	.037248	.31634
35	.16384	.039133	.32473
36	.16657	.041077	.33321
37	.16928	.043083	.34176
38	.17198	.045154	.35041
39	.17467	.047292	.35917
40	.17735	.049501	.36803
41	.18002	.051784	.37701
42	.18269	.054145	.38612
43	.18535	.056587	.39537
44	.18802	.059115	.40477
45	.19068	.061734	.41433

$\gamma = 11.7$

φ	X	Y	T
1.5°	.04854	.000795	.03475
1.4	.04087	.000601	.03109
1.3	.03521	.000467	.02795
1.2	.03059	.000366	.02511
1.1	.02665	.000287	.02240

$\gamma = 11.8$

1.5°	.04938	.000814	.03497
1.4	.04130	.000609	.03123
1.3	.03547	.000472	.02804
1.2	.03077	.000369	.02518
1.1	.02676	.000289	.02254

$\gamma = 11.9$

1.5°	.05031	.000835	.03522
1.4	.04175	.000618	.03137
1.3	.03574	.000477	.02813
1.2	.03095	.000372	.02525
1.1	.02688	.000291	.02258

$\gamma = 12.0$

1.5°	.05127	.000858	.03549
1.4	.04222	.000628	.03152
1.3	.03602	.000482	.02824
1.2	.03113	.000375	.02531
1.1	.02701	.000292	.02263
1.0	.02342	.000227	.02013
0.8	.01731	.000130	.01551
0.6	.01216	.000067	.01127
0.4	.00767	.000028	.00731
+.2	.00365	.000007	.00357
0	.00000	.000000	.00000
—.2	.00335	.000006	.00342
0.4	.00647	.000022	.00672
0.6	.00938	.000047	.00991
0.8	.01212	.000081	.01300
1.0	.01471	.000121	.01601
1.2	.01717	.000169	.01894
1.4	.01951	.000222	.02180

$\gamma = 12.0$

φ	X	Y	T
1.6°	.02176	.000281	.02460
1.8	.02391	.000344	.02734
2.0	.02598	.000413	.03003
2.2	.02798	.000486	.03267
2.4	.02990	.000564	.03527
3.0	.03532	.000819	.04281
4	.04340	.001311	.05470
5	.05057	.001874	.06592
6	.05706	.002498	.07661
7	.06301	.003176	.08687
8	.06854	.003903	.09678
9	.07371	.004675	.10638
10	.07857	.005489	.11572
11	.08318	.006343	.12485
12	.08758	.007236	.13378
13	.09177	.008167	.14255
14	.09580	.009134	.15117
15	.09968	.010137	.15967
16	.10343	.011176	.16806
17	.10706	.012250	.17636
18	.11058	.013360	.18458
19	.11400	.014506	.19273
20	.11734	.015687	.20083
21	.12060	.016906	.20888
22	.12378	.018161	.21690
23	.12691	.019454	.22489
24	.12997	.020785	.23286
25	.13298	.022157	.24083
26	.13594	.023569	.24879
27	.13885	.025022	.25676
28	.14173	.026519	.26475
29	.14457	.028060	.27275
30	.14737	.029647	.28079
31	.15015	.031282	.28887
32	.15290	.032966	.29699
33	.15562	.034701	.30517
34	.15832	.036490	.31341
35	.16100	.038334	.32171
36	.16367	.040236	.33009
37	.16632	.042198	.33855
38	.16896	.044224	.34711
39	.17159	.046316	.35577
40	.17421	.048477	.36453
41	.17683	.050710	.37342
42	.17944	.053019	.38243
43	.18204	.055409	.39158
44	.18465	.057882	.40088
45	.18725	.060443	.41033

$\gamma = 11.0$				$\gamma = 13.0$			
φ	X	Y	T	φ	X	Y	T
0.0°	.00000	.000000	.00000	0.0°	.00000	.000000	.00000
0.2	.00337	.000006	.00343	0.2	.00334	.000006	.00342
0.4	.00651	.000022	.00674	0.4	.00643	.000022	.00670
0.6	.00946	.000048	.00995	0.6	.00930	.000047	.00987
0.8	.01224	.000082	.01307	0.8	.01200	.000080	.01293
1.0	.01489	.000123	.01610	1.0	.01454	.000120	.01591
1.2	.01741	.000172	.01907	1.2	.01694	.000166	.01881
1.4	.01981	.000226	.02197	1.4	.01923	.000218	.02164
1.6	.02212	.000287	.02482	1.6	.02142	.000275	.02440
1.8	.02433	.000352	.02759	1.8	.02351	.000337	.02710
2.0	.02647	.000423	.03032	2.0	.02552	.000404	.02975
3.0	.03615	.000843	.04332	3.0	.03455	.000796	.04232
4	.04455	.001355	.05545	4	.04233	.001270	.05399
5	.05203	.001943	.06691	5	.04922	.001811	.06499
6	.05881	.002596	.07784	6	.05545	.002410	.07546
7	.06505	.003306	.08834	7	.06115	.003059	.08550
8	.07085	.004068	.09848	8	.06644	.003754	.09519
9	.07627	.004878	.10832	9	.07138	.004492	.10458
10	.08139	.005734	.11790	10	.07603	.005270	.11371
11	.08624	.006632	.12726	11	.08043	.006085	.12262
12	.09086	.007572	.13642	12	.08462	.006937	.13135
13	.09527	.008551	.14542	13	.08862	.007824	.13991
14	.09952	.009570	.15427	14	.09246	.008746	.14833
15	.10361	.010627	.16299	15	.09615	.009701	.15662
16	.10756	.011722	.17161	16	.09972	.010691	.16481
17	.11138	.012855	.18013	17	.10318	.011714	.17291
18	.11509	.014025	.18857	18	.10653	.012770	.18093
19	.11871	.015234	.19694	19	.10979	.013860	.18888
20	.12223	.016481	.20526	20	.11296	.014984	.19678
21	.12567	.017767	.21353	21	.11606	.016143	.20463
22	.12903	.019092	.22177	22	.11909	.017337	.21245
23	.13233	.020457	.22998	23	.12206	.018567	.22024
24	.13556	.021863	.23818	24	.12497	.019833	.22801
25	.13874	.023312	.24636	25	.12783	.021137	.23578
26	.14187	.024803	.25455	26	.13065	.022479	.24354
27	.14495	.026339	.26274	27	.13342	.023860	.25131
28	.14799	.027921	.27095	28	.13615	.025283	.25910
29	.15099	.029549	.27918	29	.13885	.026747	.26691
30	.15395	.031227	.28745	30	.14151	.028255	.27474
31	.15688	.032955	.29575	31	.14415	.029808	.28261
32	.15979	.034735	.30410	32	.14676	.031407	.29053
33	.16267	.036570	.31251	33	.14935	.033056	.29850
34	.16553	.038462	.32098	34	.15191	.034755	.30652
35	.16836	.040412	.32952	35	.15446	.036506	.31462
36	.17118	.042424	.33814	36	.15699	.038312	.32278
37	.17399	.044500	.34684	37	.15951	.040176	.33103
38	.17678	.046643	.35564	38	.16202	.042099	.33937
39	.17956	.048856	.36455	39	.16451	.044085	.34780
40	.18234	.051142	.37356	40	.16700	.046137	.35635

$\gamma = 14.0$				$\gamma = 15.0$			
φ	X	Y	T	φ	X	Y	T
0.0°	.00000	.000000	.00000	0.0°	.00000	.000000	.00000
0.2	.00333	.000006	.00341	0.2	.00332	.000006	.00341
0.4	.00639	.000022	.00668	0.4	.00636	.000022	.00666
0.6	.00923	.000046	.00983	0.6	.00916	.000046	.00979
0.8	.01188	.000079	.01287	0.8	.01177	.000078	.01280
1.0	.01437	.000118	.01582	1.0	.01421	.000116	.01573
1.2	.01673	.000163	.01869	1.2	.01652	.000161	.01857
1.4	.01896	.000214	.02148	1.4	.01870	.000210	.02133
1.6	.02109	.000269	.02421	1.6	.02077	.000364	.02402
1.8	.02313	.000330	.02688	1.8	.02277	.000324	.02666
2.0	.02508	.000395	.02949	2.0	.02467	.000386	.02923
3.0	.03384	.000775	.04186	3.0	.03317	.000756	.04142
4	.04135	.001233	.05333	4	.04043	.001199	.05270
5	.04799	.001754	.06412	5	.04684	.001701	.06330
6	.05398	.002329	.07439	6	.05260	.002255	.07338
7	.05945	.002953	.08423	7	.05787	.002856	.08303
8	.06452	.003619	.09372	8	.06275	.003496	.09234
9	.06926	.004326	.10291	9	.06730	.004176	.10134
10	.07371	.005071	.11184	10	.07158	.004891	.11011
11	.07792	.005852	.12057	11	.07562	.005640	.11865
12	.08193	.006667	.12910	12	.07947	.006422	.12701
13	.08576	.007515	.13747	13	.08314	.007236	.13521
14	.08943	.008396	.14571	14	.08666	.008080	.14327
15	.09296	.009310	.15382	15	.09004	.008956	.15122
16	.09637	.010255	.16182	16	.09332	.009862	.15905
17	.09967	.011232	.16974	17	.09648	.010798	.16679
18	.10287	.012241	.17758	18	.09954	.011765	.17447
19	.10599	.013282	.18535	19	.10252	.012762	.18207
20	.10902	.014356	.19306	20	.10543	.013790	.18962
21	.11198	.015462	.20074	21	.10826	.014849	.19713
22	.11487	.016601	.20837	22	.11103	.015940	.20460
23	.11770	.017775	.21599	23	.11374	.017063	.21205
24	.12048	.018983	.22358	24	.11639	.018220	.21948
25	.12321	.020227	.23116	25	.11901	.019410	.22689
26	.12589	.021507	.23875	26	.12158	.020635	.23431
27	.12854	.022825	.24634	27	.12411	.021897	.24174
28	.13114	.024181	.25394	28	.12661	.023194	.24917
29	.13372	.025578	.26156	29	.12907	.024530	.25663
30	.13626	.027016	.26922	30	.13150	.025906	.26411
31	.13877	.028497	.27690	31	.13391	.027323	.27164
32	.14126	.030022	.28463	32	.13628	.028781	.27919
33	.14373	.031593	.29241	33	.13864	.030283	.28680
34	.14617	.033213	.30025	34	.14098	.031832	.29447
35	.14860	.034882	.30815	35	.14331	.033429	.30219
36	.15102	.036604	.31613	36	.14562	.035075	.31000
37	.15342	.038380	.32418	37	.14791	.036773	.31787
38	.15581	.040213	.33232	38	.15020	.038526	.32582
39	.15819	.042105	.34055	39	.15247	.040335	.33387
40	.16056	.044060	.34889	40	.15474	.042203	.34203

γ = 16.0				γ = 17.0			
φ	X	Y	T	φ	X	Y	T
0,0°	.00000	.000000	.00000	0.0°	.00000	.000000	.00000
0,2	.00331	.000006	.00340	0,2	.00330	.000006	.00339
0.4	.00632	.000021	.00664	0.4	.00629	.000021	.00662
0,6	.00909	.000045	.00975	0.6	.00902	.000045	.00971
0,8	.01166	.000077	.01274	0.8	.01155	.000076	.01268
1.0	.01406	.000114	.01564	1.0	.01391	.000113	.01555
1,2	.01632	.000158	.01845	1,2	.01613	.000155	.01834
1.4	.01845	.000206	.02118	1.4	.01822	.000203	.02104
1,6	.02048	.000259	.02384	1,6	.02020	.000255	.02367
1,8	.02242	.000317	.02644	1.8	.02209	.000311	.02624
2.0	.02427	.000378	.02899	2,0	.02390	.000371	.02876
3,0	.03253	.000737	.04100	3.0	.03193	.000720	.04060
4	.03957	.001166	.05210	4	.03876	.001136	.05154
5	.04576	.001652	.06253	5	.04475	.001607	.06180
6	.05133	.002187	.07243	6	.05014	.002124	.07154
7	.05641	.002766	.08191	7	.05505	.002684	.08085
8	.06111	.003384	.09104	8	.05959	.003280	.08983
9	.06549	.004038	.09988	9	.06382	.003911	.09851
10	.06961	.004726	.10848	10	.06778	.004575	.10695
11	.07350	.005447	.11686	11	.07154	.005270	.11518
12	.07720	.006199	.12506	12	.07510	.005995	.12323
13	.08073	.006982	.13310	13	.07851	.006750	.13113
14	.08411	.007794	.14100	14	.08176	.007532	.13888
15	.08737	.008635	.14879	15	.08490	.008343	.14652
16	.09051	.009506	.15647	16	.08792	.009181	.15406
17	.09355	.010405	.16406	17	.09084	.010046	.16151
18	.09649	.011334	.17158	18	.09368	.010941	.16888
19	.09935	.012291	.17903	19	.09644	.011862	.17620
20	.10214	.013278	.18643	20	.09912	.012812	.18345
21	.10486	.014295	.19378	21	.10173	.013790	.19067
22	.10752	.015342	.20111	22	.10430	.014798	.19786
23	.11012	.016420	.20840	23	.10680	.015836	.20501
24	.11267	.017530	.21568	24	.10926	.016903	.21215
25	.11518	.018672	.22295	25	.11167	.018001	.21928
26	.11765	.019848	.23021	26	.11404	.019133	.22640
27	.12007	.021058	.23749	27	.11637	.020296	.23354
28	.12247	.022303	.24477	28	.11868	.021494	.24068
29	.12483	.023584	.25207	29	.12094	.022726	.24784
30	.12716	.024904	.25940	30	.12319	.023995	.25503
31	.12947	.026263	.26677	31	.12540	.025301	.26225
32	.13175	.027662	.27417	32	.12760	.026647	.26951
33	.13401	.029103	.28162	33	.12977	.028033	.27682
34	.13626	.030588	.28913	34	.13194	.029460	.28418
35	.13849	.032119	.29669	35	.13408	.030931	.29159
36	.14070	.033698	.30433	36	.13621	.032450	.29907
37	.14290	.035326	.31204	37	.13832	.034015	.30664
38	.14509	.037007	.31983	38	.14042	.035630	.31428
39	.14727	.038742	.32771	39	.14252	.037298	.32201
40	.14944	.040533	.33570	40	.14460	.039020	.32984

$\gamma = 18.0$				$\gamma = 19.0$			
φ	X	Y	T	φ	X	Y	T
0.0°	.00000	.000000	.00000	0.0°	.00000	.000000	.00000
0.2	.00329	.000006	.00339	0.2	.00328	.000006	.00338
0.4	.00625	.000021	.00660	0.4	.00622	.000021	.00659
0.6	.00895	.000045	.00967	0.6	.00889	.000044	.00964
0.8	.01144	.000075	.01262	0.8	.01134	.000074	.01257
1.0	.01376	.000111	.01547	1.0	.01363	.000110	.01539
1.2	.01594	.000153	.01823	1.2	.01576	.000151	.01812
1.4	.01799	.000200	.02090	1.4	.01777	.000196	.02077
1.6	.01993	.000250	.02351	1.6	.01967	.000246	.02335
1.8	.02178	.000305	.02605	1.8	.02148	.000299	.02586
2.0	.02354	.000364	.02853	2.0	.02320	.000357	.02831
3.0	.03136	.000703	.04022	3.0	.03082	.000688	.03985
4	.03800	.001107	.05100	4	.03728	.001081	.05048
5	.04381	.001564	.06110	5	.04293	.001524	.06044
6	.04903	.002066	.07069	6	.04799	.002011	.06988
7	.05378	.002607	.07985	7	.05260	.002535	.07890
8	.05817	.003184	.08868	8	.05684	.003094	.08759
9	.06226	.003794	.09722	9	.06081	.003685	.09600
10	.06609	.004436	.10551	10	.06452	.004307	.10415
11	.06972	.005107	.11360	11	.06803	.004956	.11211
12	.07316	.005808	.12151	12	.07135	.005634	.11989
13	.07645	.006536	.12927	13	.07453	.006338	.12752
14	.07959	.007291	.13689	14	.07757	.007068	.13502
15	.08262	.008073	.14439	15	.08050	.007824	.14239
16	.08553	.008882	.15180	16	.08332	.008606	.14967
17	.08835	.009717	.15912	17	.08604	.009413	.15687
18	.09109	.010579	.16636	18	.08869	.010246	.16399
19	.09375	.011468	.17354	19	.09126	.011106	.17105
20	.09634	.012385	.18067	20	.09376	.011991	.17806
21	.09886	.013328	.18776	21	.09620	.012903	.18502
22	.10133	.014300	.19481	22	.09858	.013841	.19195
23	.10374	.015300	.20184	23	.10091	.014807	.19886
24	.10611	.016329	.20885	24	.10320	.015801	.20575
25	.10843	.017388	.21585	25	.10544	.016824	.21263
26	.11072	.018478	.22284	26	.10765	.017877	.21950
27	.11297	.019600	.22985	27	.10982	.018960	.22638
28	.11519	.020754	.23686	28	.11196	.020075	.23327
29	.11737	.021942	.24389	29	.11408	.021221	.24019
30	.11954	.023164	.25095	30	.11617	.022402	.24712
31	.12167	.024423	.25803	31	.11823	.023618	.25409
32	.12379	.025720	.26516	32	.12028	.024868	.26108
33	.12588	.027055	.27233	33	.12229	.026158	.26813
34	.12796	.028431	.27956	34	.12429	.027487	.27523
35	.13003	.029849	.28684	35	.12629	.028857	.28239
36	.13208	.031311	.29418	36	.12827	.030267	.28961
37	.13412	.032819	.30160	37	.13025	.031723	.29689
38	.13614	.034375	.30910	38	.13220	.033225	.30426
39	.13816	.035981	.31669	39	.13414	.034775	.31172
40	.14017	.037640	.32437	40	.13609	.036376	.31926

$\gamma = 20.0$				$\gamma = 21.0$			
φ	X	Y	T	φ	X	Y	T
0.0°	.00000	.000000	.00000	0.0°	.00000	.000000	.00000
0.2	.00327	.000006	.00338	0.2	.00326	.000006	.00337
0.4	.00619	.000021	.00657	0.4	.00615	.000021	.00655
0.6	.00882	.000044	.00960	0.6	.00876	.000043	.00957
0.8	.01125	.000073	.01251	0.8	.01115	.000072	.01246
1.0	.01349	.000108	.01531	1.0	.01336	.000107	.01523
1.2	.01559	.000149	.01801	1.2	.01542	.000147	.01791
1.4	.01756	.000193	.02064	1.4	.01735	.000191	.02051
1.6	.01942	.000242	.02319	1.6	.01918	.000238	.02304
1.8	.02119	.000294	.02567	1.8	.02091	.000290	.02549
2.0	.02287	.000350	.02810	2.0	.02255	.000344	.02790
3.0	.03031	.000673	.03950	3.0	.02982	.000659	.03916
4	.03660	.001056	.04999	4	.03595	.001032	.04952
5	.04209	.001487	.05981	5	.04129	.001453	.05921
6	.04700	.001960	.06911	6	.04607	.001912	.06838
7	.05148	.002469	.07800	7	.05043	.002407	.07714
8	.05560	.003011	.08656	8	.05443	.002934	.08558
9	.05944	.003584	.09484	9	.05815	.003490	.09374
10	.06304	.004187	.10287	10	.06165	.004075	.10166
11	.06644	.004816	.11071	11	.06495	.004686	.10938
12	.06966	.005472	.11836	12	.06808	.005323	.11691
13	.07274	.006155	.12587	13	.07106	.005985	.12431
14	.07569	.006862	.13325	14	.07393	.006671	.13158
15	.07852	.007594	.14051	15	.07667	.007381	.13873
16	.08125	.008351	.14767	16	.07931	.008115	.14578
17	.08389	.009133	.15475	17	.08188	.008873	.15274
18	.08645	.009939	.16176	18	.08436	.009655	.15965
19	.08894	.010771	.16870	19	.08677	.010461	.16649
20	.09136	.011628	.17560	20	.08911	.011291	.17328
21	.09372	.012510	.18245	21	.09140	.012146	.18002
22	.09602	.013418	.18927	22	.09363	.013027	.18674
23	.09828	.014353	.19606	23	.09582	.013933	.19342
24	.10049	.015315	.20284	24	.09796	.014866	.20010
25	.10266	.016304	.20960	25	.10007	.015824	.20675
26	.10479	.017323	.21637	26	.10214	.016811	.21342
27	.10690	.018371	.22313	27	.10418	.017826	.22007
28	.10897	.019449	.22991	28	.10618	.018870	.22672
29	.11102	.020558	.23671	29	.10817	.019945	.23343
30	.11303	.021700	.24353	30	.11011	.021051	.24014
31	.11503	.022876	.25038	31	.11205	.022191	.24689
32	.11701	.024086	.25726	32	.11396	.023364	.25366
33	.11896	.025333	.26419	33	.11585	.024570	.26048
34	.12090	.026618	.27117	34	.11774	.025815	.26735
35	.12283	.027942	.27821	35	.11961	.027097	.27428
36	.12474	.029307	.28531	36	.12145	.028420	.28126
37	.12665	.030714	.29248	37	.12330	.029783	.28832
38	.12854	.032167	.29972	38	.12513	.031190	.29545
39	.13042	.033666	.30705	39	.12696	.032641	.30266
40	.13230	.035214	.31447	40	.12877	.034142	.30997

γ = 22.0				γ = 23.0			
φ	X	Y	T	φ	X	Y	T
0°.0	.00000	.000000	.00000	0°.0	.00000	.000000	.00000
0.2	.00325	.000006	.00337	0.2	.00324	.000006	.00336
0.4	.00612	.000020	.00653	0.4	.00609	.000020	.00652
0.6	.00870	.000043	.00954	0.6	.00864	.000043	.00950
0.8	.01106	.000072	.01240	0.8	.01097	.000071	.01235
1.0	.01323	.000106	.01516	1.0	.01311	.000105	.01508
1.2	.01526	.000145	.01782	1.2	.01510	.000143	.01772
1.4	.01715	.000188	.02039	1.4	.01696	.000185	.02027
1.6	.01894	.000234	.02289	1.6	.01872	.000231	.02275
1.8	.02064	.000285	.02532	1.8	.02038	.000281	.02516
2.0	.02225	.000338	.02770	2.0	.02196	.000333	.02751
3.0	.02936	.000646	.03884	3.0	.02891	.000634	.03853
4	.03533	.001010	.04907	4	.03475	.000989	.04864
5	.04054	.001420	.05863	5	.03983	.001388	.05808
6	.04519	.001867	.06769	6	.04436	.001824	.06702
7	.04943	.002349	.07633	7	.04848	.002294	.07555
8	.05332	.002861	.08465	8	.05228	.002792	.08376
9	.05694	.003402	.09269	9	.05580	.003319	.09169
10	.06034	.003970	.10050	10	.05910	.003872	.09939
11	.06355	.004564	.10811	11	.06223	.004450	.10690
12	.06659	.005183	.11554	12	.06518	.005052	.11423
13	.06949	.005826	.12283	13	.06801	.005677	.12142
14	.07227	.006492	.12999	14	.07071	.006325	.12848
15	.07493	.007182	.13704	15	.07330	.006996	.13543
16	.07750	.007895	.14399	16	.07580	.007689	.14228
17	.07999	.008631	.15085	17	.07822	.008404	.14905
18	.08240	.009390	.15765	18	.08055	.009142	.15575
19	.08474	.010172	.16439	19	.08283	.009902	.16240
20	.08701	.010978	.17108	20	.08504	.010685	.16899
21	.08923	.011808	.17772	21	.08720	.011492	.17554
22	.09140	.012663	.18434	22	.08931	.012323	.18206
23	.09352	.013542	.19092	23	.09137	.013177	.18856
24	.09560	.014447	.19750	24	.09339	.014056	.19504
25	.09765	.015377	.20406	25	.09537	.014960	.20151
26	.09965	.016335	.21062	26	.09732	.015891	.20797
27	.10163	.017320	.21718	27	.09924	.016848	.21444
28	.10358	.018333	.22375	28	.10114	.017833	.22092
29	.10550	.019376	.23034	29	.10300	.018845	.22741
30	.10739	.020449	.23695	30	.10485	.019888	.23393
31	.10927	.021554	.24359	31	.10667	.020961	.24047
32	.11112	.022692	.25027	32	.10847	.022066	.24706
33	.11296	.023863	.25698	33	.11026	.023205	.25368
34	.11479	.025070	.26375	34	.11203	.024377	.26034
35	.11660	.026314	.27057	35	.11378	.025585	.26706
36	.11839	.027597	.27745	36	.11553	.026831	.27385
37	.12018	.028919	.28440	37	.11727	.028115	.28069
38	.12196	.030284	.29142	38	.11900	.029441	.28760
39	.12373	.031692	.29852	39	.12072	.030809	.29461
40	.12549	.033146	.30572	40	.12243	.032221	.30170

γ = 24.0				γ = 25.0			
φ	X	Y	T	φ	X	Y	T
0.0°	.00000	.000000	.00000	0.0°	.00000	.000000	.00000
0.2	.00323	.000006	.00336	0.2	.00322	.000006	.00335
0.4	.00606	.000020	.00650	0.4	.00603	.000020	.00648
0.6	.00858	.000042	.00947	0.6	.00853	.000042	.00943
0.8	.01088	.000070	.01230	0.8	.01079	.000069	.01225
1.0	.01299	.000103	.01501	1.0	.01287	.000102	.01494
1.2	.01494	.000141	.01763	1.2	.01480	.000139	.01754
1.4	.01678	.000182	.02016	1.4	.01660	.000180	.02004
1.6	.01850	.000227	.02261	1.6	.01829	.000224	.02247
1.8	.02013	.000276	.02500	1.8	.01989	.000272	.02484
2.0	.02168	.000327	.02732	2.0	.02142	.000322	.02714
3.0	.02849	.000622	.03823	3.0	.02808	.000611	.03794
4	.03419	.000969	.04822	4	.03366	.000951	.04782
5	.03915	.001359	.05755	5	.03850	.001331	.05704
6	04357	.001784	.06638	6	.04282	.001746	.06577
7	.04759	.002242	.07481	7	.04674	.002193	.07410
8	.05129	.002728	.08291	8	.05035	.002667	.08210
9	.05472	.003241	.09074	9	.05370	.003168	.08983
10	.05794	.003780	.09834	10	.05684	.003693	.09733
11	.06098	.004343	.10575	11	.05980	.004242	.10465
12	.06386	.004929	.11298	12	.06261	.004813	.11179
13	.06661	.005537	.12008	13	.06529	.005406	.11880
14	.06924	.006168	.12704	14	.06785	.006021	.12567
15	.07176	.006821	.13390	15	.07031	.006657	.13244
16	.07420	.007496	.14066	16	.07268	.007314	.13912
17	.07655	.008192	.14734	17	.07498	.007993	.14571
18	.07882	.008910	.15395	18	.07719	.008692	.15223
19	.08104	.009650	.16051	19	.07935	.009413	.15870
20	.08319	.010412	.16701	20	.08145	.010156	.16512
21	.08529	.011197	.17347	21	.08349	.010920	.17149
22	.08734	.012005	.17990	22	.08549	.011708	.17784
23	.08935	.012836	.18631	23	.08744	.012517	.18416
24	.09132	.013691	.19270	24	.08936	.013350	.19047
25	.09324	.014571	.19908	25	.09124	.014206	.19676
26	.09514	.015476	.20545	26	.09309	.015088	.20305
27	.09701	.016407	.21183	27	.09491	.015994	.20935
28	.09885	.017365	.21822	28	.09669	.016927	.21565
29	.10066	.018350	.22463	29	.09846	.017886	.22198
30	.10246	.019364	.23105	30	.10021	.018874	.22831
31	.10423	.020408	.23751	31	.10194	.019891	.23469
32	.10598	.021483	.24400	32	.10364	.020937	.24109
33	.10772	.022590	.25053	33	.10533	.022015	.24753
34	.10944	.023730	.25710	34	.10701	.023125	.25402
35	.11115	.024905	.26373	35	.10868	.024269	.26057
36	.11285	.026116	.27042	36	.11033	.025448	.26716
37	.11454	.027366	.27717	37	.11197	.026665	.27383
38	.11622	.028654	.28399	38	.11360	.027919	.28056
39	.11789	.029985	.29090	39	.11523	.029214	.28737
40	.11956	.031358	.29789	40	.11686	.030551	.29427

$\gamma = 26.0$				$\gamma = 27.0$			
φ	X	Y	T	φ	X	Y	T
0.0°	.00000	.000000	.00000	0.0°	.00000	.000000	.00000
0.2	.00322	.000006	.00335	0.2	.00321	.000005	.00334
0.4	.00600	.000020	.00646	0.4	.00597	.000020	.00645
0.6	.00847	.000041	.00940	0.6	.00842	.000041	.00937
0.8	.01071	.000069	.01220	0.8	.01063	.000068	.01215
1.0	.01276	.000101	.01487	1.0	.01265	.000100	.01480
1.2	.01466	.000137	.01745	1.2	.01452	.000136	.01736
1.4	.01643	.000177	.01993	1.4	.01626	.000175	.01982
1.6	.01809	.000221	.02234	1.6	.01790	.000218	.02221
1.8	.01966	.000268	.02469	1.8	.01944	.000264	.02454
2.0	.02116	.000317	.02697	2.0	.02091	.000312	.02680
3.0	.02769	.000600	.03766	3.0	.02731	.000590	.03739
4	.03315	.000933	.04743	4	.03266	.000916	.04706
5	.03788	.001305	.05655	5	.03729	.001280	.05608
6	.04211	.001711	.06518	6	.04142	.001677	.06461
7	.04594	.002147	.07341	7	.04517	.002104	.07275
8	.04946	.002610	.08132	8	.04861	.002556	.08057
9	.05273	.003099	.08896	9	.05181	.003034	.08812
10	.05580	.003611	.09637	10	.05481	.003534	.09545
11	.05869	.004147	.10360	11	.05763	.004057	.10259
12	.06143	.004704	.11065	12	.06030	.004601	.10956
13	.06404	.005283	.11757	13	.06285	.005167	.11640
14	.06654	.005883	.12436	14	.06529	.005752	.12310
15	.06894	.006503	.13104	15	.06764	.006358	.12971
16	.07125	.007144	.13764	16	.06989	.006984	.13623
17	.07349	.007806	.14415	17	.07207	.007630	.14266
18	.07565	.008488	.15059	18	.07418	.008296	.14902
19	.07775	.009191	.15698	19	.07624	.008982	.15533
20	.07980	.009915	.16331	20	.07823	.009688	.16159
21	.08179	.010660	.16961	21	.08018	.010416	.16781
22	.08374	.011428	.17588	22	.08208	.011165	.17400
23	.08564	.012217	.18212	23	.08394	.011935	.18017
24	.08751	.013029	.18835	24	.08576	.012727	.18632
25	.08935	.013864	.19456	25	.08755	.013542	.19246
26	.09115	.014723	.20077	26	.08931	.014380	.19859
27	.09292	.015607	.20699	27	.09104	.015242	.20474
28	.09466	.016516	.21321	28	.09274	.016130	.21088
29	.09639	.017451	.21945	29	.09442	.017042	.21704
30	.09809	.018414	.22571	30	.09608	.017981	.22322
31	.09977	.019405	.23200	31	.09772	.018948	.22944
32	.10143	.020425	.23832	32	.09935	.019943	.23568
33	.10308	.021475	.24468	33	.10095	.020967	.24196
34	.10472	.022557	.25109	34	.10255	.022023	.24829
35	.10634	.023672	.25755	35	.10413	.023111	.25467
36	.10795	.024821	.26406	36	.10570	.024232	.26110
37	.10955	.026007	.27064	37	.10726	.025388	.26760
38	.11114	.027229	.27729	38	.10882	.026581	.27417
39	.11273	.028492	.28401	39	.11037	.027812	.28081
40	.11431	.029795	.29082	40	.11190	.029084	.28754

$\gamma = 28.0$				$\gamma = 29.0$			
φ	X	Y	T	φ	X	Y	T
0.0°	.00000	.000000	.00000	0.0°	.00000	.000000	.00000
0.2	.00320	.000005	.00334	0.2	.00319	.000005	.00334
0.4	.00594	.000020	.00643	0.4	.00591	.000020	.00642
0.6	.00836	.000041	.00934	0.6	.00831	.000041	.00931
0.8	.01054	.000067	.01210	0.8	.01047	.000067	.01205
1.0	.01254	.000099	.01474	1.0	.01243	.000098	.01468
1.2	.01438	.000134	.01728	1.2	.01425	.000132	.01719
1.4	.01610	.000173	.01972	1.4	.01594	.000171	.01962
1.6	.01771	.000215	.02209	1.6	.01752	.000212	.02197
1.8	.01922	.000260	.02440	1.8	.01901	.000257	.02426
2.0	.02066	.000308	.02664	2.0	.02043	.000303	.02648
3.0	.02695	.000581	.03712	3.0	.02660	.000571	.03687
4	.03219	.000900	.04670	4	.03174	.000884	.04635
5	.03673	.001256	.05562	5	.03619	.001233	.05518
6	.04077	.001645	.06406	6	.04015	.001614	.06353
7	.04444	.002062	.07211	7	.04374	.002022	.07150
8	.04780	.002505	.07984	8	.04703	.002456	.07914
9	.05093	.002972	.08731	9	.05009	.002913	.08654
10	.05386	.003461	.09456	10	.05296	.003391	.09371
11	.05662	.003972	.10161	11	.05565	.003891	.10068
12	.05923	.004504	.10851	12	.05821	.004412	.10750
13	.06172	.005057	.11527	13	.06064	.004952	.11419
14	.06411	.005629	.12190	14	.06298	.005512	.12074
15	.06640	.006221	.12843	15	.06522	.006091	.12720
16	.06860	.006832	.13487	16	.06737	.006688	.13357
17	.07073	.007463	.14123	17	.06945	.007305	.13986
18	.07279	.008114	.14752	18	.07147	.007941	.14608
19	.07480	.008784	.15375	19	.07343	.008596	.15224
20	.07675	.009474	.15994	20	.07534	.009271	.15836
21	.07865	.010185	.16609	21	.07720	.009966	.16444
22	.08050	.010916	.17221	22	.07901	.010680	.17049
23	.08232	.011668	.17830	23	.08078	.011415	.17651
24	.08410	.012442	.18438	24	.08252	.012172	.18252
25	.08585	.013238	.19045	25	.08423	.012950	.18852
26	.08756	.014056	.19651	26	.08590	.013750	.19452
27	.08925	.014898	.20258	27	.08755	.014572	.20051
28	.09092	.015765	.20865	28	.08919	.015419	.20652
29	.09256	.016656	.21474	29	.09079	.016290	.21254
30	.09418	.017573	.22085	30	.09238	.017187	.21858
31	.09578	.018517	.22699	31	.09394	.018109	.22465
32	.09737	.019488	.23316	32	.09549	.019058	.23075
33	.09894	.020489	.23937	33	.09703	.020037	.23689
34	.10049	.021520	.24562	34	.09854	.021044	.24306
35	.10204	.022582	.25192	35	.10006	.022082	.24929
36	.10357	.023676	.25828	36	.10155	.023151	.25558
37	.10510	.024805	.26470	37	.10305	.024254	.26192
38	.10662	.025970	.27119	38	.10453	.025393	.26834
39	.10813	.027172	.27775	39	.10601	.026567	.27482
40	.10963	.028413	.28440	40	.10748	.027779	.28140

$\gamma = 30.0$				$\gamma = 35$			
φ	X	Y	T	φ	X	Y	T
0.0°	.00000	.000000	.00000	0.0°	.00000	.000000	.00000
0.2	.00318	.000005	.00333	0.2	.00314	.000005	.00331
0.4	.00588	.000019	.00640	0.4	.00575	.000019	.00633
0.6	.00826	.000040	.00928	0.6	.00802	.000039	.00914
0.8	.01039	.000066	.01201	0.8	.01003	.000063	.01179
1.0	.01233	.000097	.01461	1.0	.01186	.000092	.01432
1.2	.01412	.000131	.01711	1.2	.01353	.000124	.01673
1.4	.01579	.000169	.01952	1.4	.01508	.000159	.01906
1.6	.01734	.000209	.02186	1.6	.01653	.000197	.02131
1.8	.01881	.000253	.02412	1.8	.01789	.000237	.02349
2.0	.02020	.000299	.02633	2.0	.01917	.000280	.02561
3.0	.02627	.000562	.03662	3.0	.02476	.000522	.03548
4	.03131	.000869	.04601	4	.02937	.000803	.04447
5	.03567	.001211	.05476	5	.03335	.001116	.05284
6	.03955	.001584	.06303	6	.03689	.001455	.06073
7	.04306	.001984	.07091	7	.04009	.001819	.06824
8	.04629	.002409	.07848	8	.04302	.002205	.07546
9	.04929	.002856	.08579	9	.04574	.002612	.08243
10	.05209	.003325	.09288	10	.04829	.003037	.08919
11	.05473	.003814	.09979	11	.05068	.003481	.09576
12	.05724	.004324	.10653	12	.05295	.003943	.10219
13	.05962	.004852	.11314	13	.05512	.004422	.10848
14	.06190	.005400	.11963	14	.05718	.004918	.11466
15	.06409	.005966	.12602	15	.05917	.005431	.12074
16	.06620	.006551	.13231	16	.06108	.005961	.12673
17	.06824	.007155	.13853	17	.06292	.006508	.13265
18	.07022	.007777	.14469	18	.06471	.007071	.13850
19	.07213	.008418	.15079	19	.06645	.007651	.14431
20	.07400	.009078	.15684	20	.06813	.008248	.15006
21	.07581	.009757	.16285	21	.06978	.008863	.15578
22	.07759	.010457	.16884	22	.07138	.009495	.16147
23	.07932	.011176	.17479	23	.07295	.010146	.16714
24	.08102	.011916	.18074	24	.07449	.010815	.17279
25	.08269	.012677	.18667	25	.07600	.011503	.17843
26	.08434	.013459	.19260	26	.07749	.012211	.18407
27	.08595	.014264	.19853	27	.07894	.012939	.18971
28	.08754	.015092	.20447	28	.08038	.013687	.19536
29	.08911	.015944	.21042	29	.08180	.014457	.20102
30	.09066	.016821	.21640	30	.08320	.015249	.20670
31	.09219	.017723	.22240	31	.08459	.016065	.21240
32	.09370	.018652	.22843	32	.08596	.016904	.21814
33	.09520	.019608	.23450	33	.08731	.017768	.22391
34	.09669	.020593	.24061	34	.08866	.018658	.22972
35	.09817	.021608	.24677	35	.08999	.019575	.23557
36	.09964	.022654	.25299	36	.09132	.020520	.24148
37	.10109	.023733	.25926	37	.09263	.021495	.24745
38	.10254	.024846	.26561	38	.09394	.022500	.25347
39	.10399	.025994	.27202	39	.09525	.023538	.25957
40	.10543	.027180	.27851	40	.09655	.024609	.26574

$\gamma = 40$				$\gamma = 45$			
φ	X	Y	T	φ	X	Y	T
0.0°	.00000	.000000	.00000	0.0°	.00000	.000000	.00000
0.2	.00309	.000005	.00328	0.2	.00306	.000005	.00326
0.4	.00562	.000018	.00625	0.4	.00551	.000018	.00619
0.6	.00779	.000037	.00901	0.6	.00759	.000036	.00888
0.8	.00971	.000061	.01159	0.8	.00942	.000058	.01141
1.0	.01143	.000088	.01405	1.0	.01105	.000084	.01380
1.2	.01301	.000118	.01639	1.2	.01254	.000112	.01608
1.4	.01446	.000151	.01864	1.4	.01392	.000144	.01827
1.6	.01582	.000186	.02082	1.6	.01519	.000177	.02038
1.8	.01709	.000224	.02293	1.8	.01639	.000212	.02242
2.0	.01828	.000264	.02497	2.0	.01751	.000250	.02440
3.0	.02347	.000488	.03449	3.0	.02236	.000460	.03361
4	.02774	.000748	.04314	4	.02635	.000703	.04196
5	.03142	.001037	.05117	5	.02977	.000972	.04971
6	.03468	.001351	.05875	6	.03280	.001263	.05702
7	.03762	.001686	.06596	7	.03554	.001574	.06397
8	.04032	.002041	.07288	8	.03804	.001904	.07064
9	.04282	.002414	.07956	9	.04037	.002251	.07708
10	.04516	.002805	.08604	10	.04254	.002613	.08332
11	.04736	.003213	.09235	11	.04458	.002992	.08939
12	.04945	.003637	.09850	12	.04651	.003385	.09531
13	.05143	.004077	.10453	13	.04835	.003793	.10112
14	.05333	.004532	.11045	14	.05011	.004215	.10681
15	.05515	.005003	.11627	15	.05179	.004651	.11242
16	.05690	.005489	.12201	16	.05342	.005101	.11794
17	.05859	.005990	.12768	17	.05498	.005565	.12340
18	.06023	.006507	.13328	18	.05650	.006044	.12879
19	.06182	.007039	.13884	19	.05797	.006536	.13414
20	.06337	.007586	.14435	20	.05941	.007043	.13944
21	.06488	.008150	.14983	21	.06080	.007565	.14471
22	.06635	.008729	.15527	22	.06216	.008102	.14995
23	.06779	.009326	.16070	23	.06350	.008654	.15517
24	.06920	.009939	.16611	24	.06480	.009221	.16038
25	.07058	.010569	.17151	25	.06608	.009805	.16557
26	.07194	.011217	.17691	26	.06734	.010405	.17076
27	.07328	.011884	.18230	27	.06858	.011022	.17596
✓ 28	.07459	.012570	.18771	28	.06980	.011657	.18116
29	.07589	.013275	.19313	29	.07100	.012310	.18637
30	.07718	.014001	.19857	30	.07219	.012981	.19160
31	.07844	.014748	.20402	31	.07336	.013672	.19685
32	.07970	.015516	.20951	32	.07452	.014383	.20213
33	.08094	.016308	.21503	33	.07567	.015116	.20744
34	.08217	.017123	.22059	34	.07681	.015870	.21279
35	.08339	.017963	.22620	35	.07794	.016647	.21818
36	.08461	.018828	.23185	36	.07907	.017448	.22362
37	.08581	.019720	.23756	37	.08018	.018273	.22911
38	.08701	.020641	.24333	38	.08129	.019125	.23465
39	.08821	.021591	.24916	39	.08240	.020003	.24027
40	.08940	.022571	.25506	40	.08350	.020911	.24595

$\gamma = 50$				$\gamma = 55$			
φ	X	Y	T	φ	X	Y	T
$\overset{\circ}{0}.0$	.00000	.000000	.00000	$\overset{\circ}{0}.0$	.00000	.000000	.00000
0.2	.00302	.000005	.00324	0.2	.00298	.000005	.00322
0.4	.00540	.000017	.00613	0.4	.00530	.000017	.00606
0.6	.00740	.000035	.00877	0.6	.00723	.000034	.00866
0.8	.00915	.000056	.01124	0.8	.00890	.000054	.01108
1.0	.01071	.000081	.01357	1.0	.01039	.000078	.01336
1.2	.01212	.000108	.01579	1.2	.01174	.000103	.01553
1.4	.01342	.000137	.01792	1.4	.01298	.000132	.01761
1.6	.01463	.000169	.01998	1.6	.01413	.000162	.01961
1.8	.01576	.000202	.02196	1.8	.01520	.000193	.02154
2.0	.01682	.000237	.02389	2.0	.01620	.000227	.02342
3.0	.02139	.000435	.03282	3.0	.02052	.000414	.03211
4	.02513	.000663	.04091	4	.02406	.000629	.03997
5	.02834	.000915	.04842	5	.02708	.000867	.04726
6	.03117	.001188	.05549	6	.02976	.001124	.05412
7	.03374	.001480	.06222	7	.03217	.001398	.06065
8	.03608	.001788	.06867	8	.03438	.001688	.06691
9	.03825	.002112	.07490	9	.03642	.001994	.07295
10	.04028	.002451	.08093	10	.03833	.002313	.07880
11	.04219	.002805	.08680	11	.04012	.002645	.08449
12	.04400	.003172	.09253	12	.04182	.002990	.09004
13	.04571	.003553	.09813	13	.04343	.003348	.09548
14	.04736	.003947	.10364	14	.04498	.003719	.10082
15	.04893	.004354	.10905	15	.04646	.004101	.10607
16	.05045	.004774	.11439	16	.04788	.004496	.11124
17	.05191	.005208	.11966	17	.04926	.004904	.11635
18	.05333	.005655	.12488	18	.05059	.005323	.12141
19	.05470	.006114	.13004	19	.05188	.005756	.12641
20	.05604	.006588	.13517	20	.05314	.006200	.13138
21	.05734	.007075	.14026	21	.05436	.006658	.13632
22	.05861	.007576	.14532	22	.05556	.007128	.14122
23	.05985	.008091	.15036	23	.05673	.007612	.14611
24	.06107	.008620	.15539	24	.05787	.008110	.15098
25	.06227	·009165	.16041	25	.05899	.008621	.15585
26	.06344	.009725	.16542	26	.06009	.009147	.16071
27	.06460	.010300	.17044	27	.06118	.009688	.16557
28	.06573	.010892	.17546	28	.06225	.010244	.17043
29	.06685	.011501	.18050	29	.06330	.010816	.17531
30	.06796	.012128	.18555	30	.06434	.011404	.18021
31	.06906	.012772	.19062	31	.06537	.012009	.18512
32	.07014	.013436	.19572	32	.06638	.012632	.19006
33	.07121	.014119	.20085	33	.06739	.013273	.19503
34	.07227	.014822	.20601	34	.06839	.013934	.20004
35	.07333	.015547	.21122	35	.06938	.014614	.20508
36	.07437	.016294	.21647	36	.07036	.015315	.21017
37	.07542	.017064	.22177	37	.07134	.016038	.21531
38	.07645	.017858	.22713	38	.07231	.016784	.22050
39	.07748	.018678	.23255	39	.07328	.017553	.22575
40	.07851	.019524	.23803	40	.07424	.018348	.23107

$\gamma = 60$				$\gamma = 65$			
φ	X	Y	T	φ	X	Y	T
0.0°	.00000	.000000	.00000	0.0°	.00000	.000000	.00000
0.2	.00294	.000005	.00320	0.2	.00291	.000005	.00318
0.4	.00520	.000016	.00601	0.4	.00511	.000016	.00595
0.6	.00706	.000033	.00856	0.6	.00691	.000032	.00846
0.8	.00867	.000052	.01093	0.8	.00846	.000051	.01079
1.0	.01010	.000075	.01316	1.0	.00984	.000072	.01298
1.2	.01139	.000099	.01528	1.2	.01107	.000096	.01506
1.4	.01257	.000126	.01731	1.4	.01221	.000121	.01704
1.6	.01367	.000155	.01927	1.6	.01325	.000149	.01896
1.8	.01469	.000185	.02116	1.8	.01423	.000178	.02080
2.0	.01565	.000217	.02299	2.0	.01514	.000208	.02259
3.0	.01975	.000395	.03145	3.0	.01906	.000378	.03086
4	.02310	.000599	.03911	4	.02225	.000572	.03833
5	.02597	.000824	.04621	5	.02498	.000786	.04525
6	.02850	.001067	.05289	6	.02738	.001018	.05176
7	.03078	.001327	.05924	7	.02955	.001264	.05796
8	.03287	.001602	.06532	8	.03154	.001525	.06389
9	.03480	.001890	.07119	9	.03337	.001799	.06961
10	.03661	.002192	.07688	10	.03508	.002086	.07515
11	.03830	.002506	.08242	11	.03669	.002384	.08055
12	.03991	.002832	.08782	12	.03822	.002694	.08581
13	.04143	.003171	.09310	13	.03967	.003015	.09096
14	.04289	.003521	.09829	14	.04105	.003347	.09601
15	.04429	.003882	.10340	15	.04238	.003690	.10098
16	.04564	.004256	.10843	16	.04366	.004045	.10588
17	.04694	.004640	.11339	17	.04489	.004410	.11072
18	.04819	.005037	.11830	18	.04608	.004786	.11551
19	.04941	.005445	.12317	19	.04724	.005173	.12025
20	.05060	.005865	.12800	20	.04837	.005571	.12495
21	.05176	.006297	.13279	21	.04946	.005981	.12962
22	.05288	.006741	.13756	22	.05053	.006403	.13426
23	.05399	.007198	.14231	23	.05158	.006836	.13889
24	.05507	.007668	.14704	24	.05260	.007282	.14350
25	.05613	.008151	.15177	25	.05361	.007740	.14811
26	.05717	.008647	.15649	26	.05460	.008211	.15271
27	.05819	.009158	.16122	27	.05557	.008695	.15731
28	.05920	.009683	.16595	28	.05653	.009193	.16191
29	.06019	.010223	.17069	29	.05747	.009705	.16653
30	.06118	.010778	.17544	30	.05840	.010232	.17116
31	.06215	.011350	.18022	31	.05932	.010774	.17581
32	.06311	.011938	.18502	32	.06023	.011332	.18049
33	.06406	.012543	.18985	33	.06113	.011906	.18519
34	.06500	.013167	.19471	34	.06203	.012497	.18993
25	.06593	.013809	.19961	35	.06291	.013107	.19470
36	.06686	.014471	.20455	36	.06379	.013734	.19951
37	.06778	.015154	.20954	37	.06467	.014381	.20437
38	.06870	.015858	.21459	38	.06554	.015049	.20928
39	.06961	.016584	.21969	39	.06640	.015738	.21425
40	.07052	.017334	.22485	40	.06726	.016449	.21928

γ = 70				γ = 80			
φ	X	Y	T	φ	X	Y	T
0°,0	.00000	.000000	.00000	0°.0	.00000	.000000	.00000
0.2	.00288	.000005	.00317	0.2	.00282	.000005	.00313
0.4	.00502	.000016	.00590	0.4	.00486	.000015	.00580
0,6	.00677	.000031	.00837	0,6	.00651	.000029	.00820
0.8	.00827	.000049	.01066	0,8	.00792	.000047	.01041
1,0	.00959	.000070	.01280	1.0	.00915	.000066	.01249
1,2	.01078	.000093	.01484	1,2	.01026	.000087	.01445
1.4	.01188	.000118	.01679	1.4	.01127	.000110	.01633
1,6	.01287	.000144	.01866	1.6	.01220	.000134	.01813
1.8	.01381	.000171	.02047	1,8	.01306	.000160	.01987
2,0	.01468	.000201	.02222	2,0	.01387	.000187	.02155
3.0	.01843	.000363	.03031	3.0	.01733	.000337	.02933
4	.02148	.000548	.03761	4	.02013	.000507	.03633
5	.02408	.000753	.04438	5	.02253	.000695	.04281
6	.02638	.000974	.05074	6	.02464	.000898	.04891
7	.02845	.001209	.05678	7	.02653	.001114	.05470
8	.03034	.001458	.06258	8	.02827	.001342	.06025
9	.03209	.001719	.06816	9	.02987	.001582	.06560
10	.03372	.001992	.07358	10	.03137	.001832	.07078
11	.03525	.002276	.07884	11	.03278	.002093	.07582
12	.03671	.002571	.08398	12	.03411	.002363	.08074
13	.03809	.002877	.08901	13	.03537	.002644	.08556
14	.03941	.003194	.09394	14	.03658	.002934	.09028
15	.04067	.003521	.09879	15	.03774	.003233	.09492
16	.04189	.003858	.10357	16	.03885	.003542	.09950
17	.04306	.004206	.10829	17	.03993	.003861	.10402
18	.04420	.004564	.11296	18	.04097	.004189	.10849
19	.04530	.004933	.11759	19	.04198	.004527	.11291
20	.04637	.005313	.12218	20	.04296	.004874	.11730
21	.04742	.005703	.12674	21	.04392	.005232	.12167
22	.04844	.006104	.13127	22	.04485	.005599	.12600
23	.04943	.006517	.13578	23	.04576	.005977	.13032
24	.05041	.006942	.14028	24	.04666	.006366	.13463
25	.05137	.007378	.14477	25	.04754	.006765	.13893
26	.05231	.007826	.14926	26	.04840	.007176	.14323
27	.05323	.008287	.15375	27	.04924	.007598	.14752
28	.05414	.008761	.15825	28	.05008	.008032	.15182
29	.05504	.009249	.16275	29	.05090	.008479	.15613
30	.05592	.009751	.16727	30	.05171	.008938	.16046
31	.05680	.010267	.17181	31	.05251	.009410	.16480
32	.05767	.010798	.17637	32	.05331	.009896	.16917
33	.05853	.011344	.18096	33	.05409	.010397	.17356
34	.05938	.011908	.18558	34	.05487	.010912	.17798
35	.06022	.012488	.19024	35	.05564	.011443	.18243
36	.06106	.013085	.19493	36	.05641	.011990	.18693
37	.06189	.013701	.19968	37	.05717	.012554	.19146
38	.06272	.014337	.20447	38	.05793	.013136	.19605
39	.06354	.014993	.20932	39	.05868	.013736	.20068
40	.06436	.015669	.21422	40	.05944	.014355	.20538

$\gamma = 90$				$\gamma = 100$			
φ	X	Y	T	φ	X	Y	T
0°.0	.00000	.000000	.00000	0°.0	.00000	.000000	.00000
0.2	.00276	.000004	.00310	0.2	.00271	.000004	.00306
0.4	.00472	.000014	.00571	0.4	.00458	.000014	.00562
0.6	.00628	.000028	.00804	0.6	.00607	.000027	.00790
0.8	.00760	.000044	.01019	0.8	.00733	.000042	.00999
1.0	.00876	.000062	.01220	1.0	.00842	.000059	.01195
1.2	.00980	.000082	.01411	1.2	.00940	.000078	.01379
1.4	.01074	.000104	.01592	1.4	.01029	.000098	.01555
1.6	.01161	.000126	.01766	1.6	.01110	.000120	.01724
1.8	.01242	.000150	.01934	1.8	.01186	.000142	.01887
2.0	.01318	.000175	.02097	2.0	.01257	.000166	.02044
3.0	.01640	.000315	.02846	3.0	.01558	.000296	.02770
4	.01900	.000473	.03521	4	.01802	.000445	.03423
5	.02122	.000648	.04146	5	.02010	.000608	.04027
6	.02318	.000836	.04733	6	.02193	.000784	.04594
7	.02494	.001036	.05291	7	.02357	.000971	.05134
8	.02655	.001247	.05825	8	.02507	.001168	.05650
9	.02803	.001469	.06340	9	.02646	.001375	.06147
10	.02942	.001701	.06838	10	.02775	.001592	.06629
11	.03072	.001942	.07323	11	.02897	.001817	.07098
12	.03195	.002193	.07797	12	.03012	.002051	.07555
13	.03312	.002452	.08260	13	.03121	.002293	.08002
14	.03424	.002721	.08714	14	.03226	.002544	.08441
15	.03531	.002998	.09161	15	.03326	.002802	.08873
16	.03635	.003284	.09601	16	.03422	.003069	.09298
17	.03734	.003579	.10036	17	.03515	.003344	.09718
18	.03830	.003883	.10466	18	.03605	.003627	.10133
19	.03924	.004195	.10891	19	.03692	.003919	.10544
20	.04015	.004517	.11314	20	.03777	.004219	.10952
21	.04103	.004847	.11733	21	.03859	.004527	.11357
22	.04189	.005187	.12151	22	.03940	.004845	.11760
23	.04274	.005537	.12566	23	.04018	.005171	.12162
24	.04356	.005896	.12980	24	.04095	.005596	.12562
25	.04438	.006266	.13394	25	.04171	.005850	.12961
26	.04517	.006646	.13807	26	.04245	.006205	.13360
27	.04596	.007036	.14220	27	.04318	.006569	.13759
28	.04673	.007438	.14633	28	.04390	.006943	.14158
29	.04749	.007851	.15048	29	.04461	.007329	.14559
30	.04824	.008275	.15464	30	.04531	.007725	.14960
31	.04898	.008712	.15882	31	.04600	.008132	.15363
32	.04972	.009162	.16301	32	.04669	.008551	.15769
33	.05044	.009625	.16723	33	.04737	.008983	.16177
34	.05116	.010101	.17149	34	.04804	.009427	.16587
35	.05188	.010592	.17577	35	.04870	.009885	.17001
36	.05259	.011098	.18009	36	.04937	.010357	.17418
37	.05329	.011620	.18445	37	.05002	.010843	.17839
38	.05399	.012158	.18886	38	.05068	.011345	.18265
39	.05469	.012713	.19332	39	.05133	.011862	.18696
40	.05538	.013285	.19784	40	.05197	.012396	.19132

(B) VALUES OF X′ Y′ & T′.

$3p_1+p_1^3=\frac{1}{\gamma}=0.01$				$3p_1+p_1^3=\frac{1}{\gamma}=0.001$			
φ	X′	Y′	T′	φ	X′	Y′	T′
0.2°	.00000	.000000	.00000	0.2°	.00000	.000000	.00000
0.4	.04040	.000208	.01187	0.4	.05447	.000278	.01376
0.6	.07243	.000486	.02244	0.6	.09336	.000615	.02541
0.8	.09943	.000815	.03214	0.8	.12455	.000994	.03584
1.0	.12301	.001184	.04121	1.0	.15099	.001408	.04545
1.2	.14407	.001588	.04979	1.2	.17417	.001853	.05444
1.4	.16321	.002022	.05796	1.4	.19493	.002323	.06296
1.6	.18080	.002482	.06580	1.6	.21383	.002817	.07108
1.8	.19712	.002966	.07335	1.8	.23123	.003333	.07888
2.0	.21239	.003472	.08066	2.0	.24740	.003870	.08640
2.2	.22676	.003999	.08775	2.2	.26253	.004424	.09367
2.4	.24035	.004545	.09464	2.4	.27678	.004996	.10073
2.6	.25326	.005108	.10136	2.6	.29027	.005585	.10760
2.8	.26557	.005688	.10792	2.8	.30310	.006190	.11429
3.0	.27734	.006284	.11434	3.0	.31533	.006809	.12084
3.2	.28863	.006896	.12063	3.2	.32703	.007443	.12724
3.4	.29949	.007522	.12679	3.4	.33826	.008090	.13351
3.6	.30996	.008162	.13285	3.6	.34907	.008751	.13966
3.8	.32007	.008816	.13880	3.8	.35949	.009425	.14570
4.0	.32985	.009482	.14466	4.0	.36955	.010110	.15164
5.0	.37460	.012995	.17269	5.0	.41543	.013712	.18002
6	.41398	.016781	.19902	6	.45563	.017575	.20663
7	.44940	.020811	.22404	7	.49166	.021675	.23187
8	.48174	.025065	.24801	8	.52448	.025993	.25601
9	.51163	.029529	.27110	9	.55477	.030516	.27925
10	.53951	.034191	.29346	10	.58297	.035234	.30175
11	.56570	.039044	.31521	11	.60945	.040138	.32361
12	.59048	.044082	.33643	12	.63446	.045225	.34493
13	.61403	.049301	.35719	13	.65822	.050490	.36579
14	.63651	.054698	.37757	14	.68089	.055931	.38624
15	.65807	.060272	.39760	15	.70261	.061547	.40635
16	.67880	.066021	.41734	16	.72349	.067336	.42616
17	.69881	.071946	.43683	17	.74363	.073300	.44572
18	.71816	.078048	.45610	18	.76310	.079439	.46505
19	.73694	.084329	.47519	19	.78198	.085756	.48419
20	.75519	.090791	.49412	20	.80033	.092253	.50317
21	.77297	.097437	.51293	21	.81820	.098933	.52203
22	.79032	.104271	.53163	22	.83563	.105800	.54078
23	.80728	.111297	.55026	23	.85267	.112858	.55944
24	.82389	.118519	.56882	24	.86936	.120111	.57805
25	.84018	.125943	.58735	25	.88571	.127566	.59662
26	.85618	.133575	.60587	26	.90178	.135227	.61517
27	.87192	.141421	.62439	27	.91757	.143102	.63372
28	.88742	.149488	.64293	28	.93312	.151198	.65230
29	.90269	.157784	.66151	29	.94845	.159521	.67091
30	.91778	.166316	.68015	30	.96358	.168081	.68958
31	.93268	.175094	.69887	31	.97853	.176886	.70833
32	.94742	.184128	.71768	32	.99331	.185946	.72717
33	.96202	.193426	.73661	33	1.00795	.195270	.74612
34	.97648	.203001	.75566	34	1.02246	.204870	.76520
35	.99084	.212864	.77487	35	1.03684	.214758	.78443

$3p_1 + p_1^3 = \frac{1}{\gamma} = 0.0001$				$3p_1 + p_1^3 = \frac{1}{\gamma} = 0$			
φ	X′	Y′	T′	φ	X′	Y′	T′
0.2°	.00000	.000000	.00000	0.2°	.00000	.000000	.00000
0.4	.05669	.000289	.01403	0.4	.05701	.000290	.01407
0.6	.09649	.000633	.02581	0.6	.09691	.000635	.02586
0.8	.12819	.001019	.03633	0.8	.12867	.001021	.03639
1.0	.15497	.001438	.04600	1.0	.15549	.001442	.04608
1.2	.17839	.001887	.05504	1.2	.17894	.001891	.05511
1.4	.19934	.002362	.06359	1.4	.19991	.002366	.06366
1.6	.21838	.002860	.07175	1.6	.21897	.002865	.07182
1.8	.23589	.003379	.07957	1.8	.23650	.003385	.07965
2.0	.25216	.003919	.08711	2.0	.25277	.003924	.08719
2.2	.26738	.004476	.09440	2.2	.26800	.004482	.09448
2.4	.28170	.005052	.10148	2.4	.28233	.005058	.10156
2.6	.29525	.005643	.10836	2.6	.29589	.005649	.10845
2.8	.30813	.006250	.11507	2.8	.30877	.006257	.11516
3.0	.32041	.006872	.12163	3.0	.32106	.006879	.12172
3.2	.33215	.007508	.12804	3.2	.33281	.007515	.12813
3.4	.34342	.008158	.13432	3.4	.34408	.008165	.13441
3.6	.35426	.008821	.14049	3.6	.35493	.008828	.14058
3.8	.36471	.009496	.14654	3.8	.36538	.009504	.14663
4.0	.37480	.010184	.15249	4.0	.37547	.010192	.15258
5.0	.42080	.013795	.18090	5.0	.42148	.013803	.18100
6	.46108	.017666	.20754	6	.46177	.017676	.20764
7	.49717	.021773	.23280	7	.49787	.021784	.23290
8	.53005	.026098	.25696	8	.53076	.026109	.25706
9	.56038	.030627	.28022	9	.56109	.030638	.28032
10	.58862	.035350	.30272	10	.58933	.035362	.30283
11	.61512	.040260	.32460	11	.61584	.040273	.32470
12	.64016	.045351	.34593	12	.64088	.045365	.34604
13	.66394	.050621	.36680	13	.66466	.050635	.36690
14	.68662	.056067	.38726	14	.68735	.056081	.38737
15	.70836	.061686	.40738	15	.70908	.061701	.40749
16	.72925	.067480	.42720	16	.72998	.067495	.42731
17	.74940	.073448	.44675	17	.75013	.073463	.44687
18	.76889	.079591	.46609	18	.76962	.079607	.46620
19	.78778	.085911	.48524	19	.78851	.085928	.48535
20	.80614	.092412	.50423	20	.80687	.092429	.50434
21	.82402	.099095	.52309	21	.82475	.099113	.52320
22	.84146	.105965	.54184	22	.84219	.105983	.54195
23	.85851	.113026	.56051	23	.85924	.113044	.56063
24	.87520	.120283	.57912	24	.87593	.120301	.57924
25	.89156	.127740	.59769	25	.89230	.127759	.59781
26	.90763	.135405	.61625	26	.90837	.135424	.61637
27	.92343	.143283	.63480	27	.92417	.143302	.63492
28	.93899	.151381	.65338	28	.93973	.151401	.65350
29	.95433	.159707	.67200	29	.95506	.159727	.67212
30	.96946	.168270	.69067	30	.97020	.168290	.69079
31	.98441	.177078	.70942	31	.98515	.177098	.70954
32	.99920	.186140	.72826	32	.99994	.186161	.72838
33	1.01384	.195467	.74722	33	1.01458	.195488	.74734
34	1.02835	.205069	.76630	34	1.02909	.205091	.76642
35	1.04274	.214959	.78553	35	1.04348	.214981	.78565

(C) COEFFICIENTS FOR THE CUBIC LAW OF RESISTANCE TO OGIVAL HEADED SHOT.

V f-s	K_v	ΣK_v	$\frac{K_v}{g}$	$\Sigma\frac{K_v}{g}$	V f-s	K_v	ΣK_v	$\frac{K_v}{g}$	$\Sigma\frac{K_v}{g}$
900	64.4	64	2.001	2.00	1400	104.0	4914	3.231	152.65
910	64.8	129	2.014	4.02	1410	103.4	5017	3.212	155.86
920	65.3	195	2.029	6.04	1420	102.8	5120	3.193	159.06
930	65.9	260	2.047	8.09	1430	102.2	5222	3.175	162.23
940	66.6	327	2.069	10.16	1440	101.6	5324	3.155	165.39
950	67.4	394	2.094	12.25	1450	100.9	5425	3.134	168.52
960	68.4	463	2.125	14.38	1460	100.2	5525	3.112	171.63
970	69.6	532	2.162	16.54	1470	99.4	5624	3.089	174.72
980	71.0	603	2.206	18.75	1480	98.7	5723	3.065	177.79
990	72.8	676	2.262	21.01	1490	97.9	5821	3.041	180.83
1000	75.0	751	2.330	23.34	1500	97.2	5918	3.018	183.85
1010	77.5	829	2.408	25.75	1510	96.4	6015	2.994	186.84
1020	80.4	909	2.498	28.25	1520	95.5	6110	2.968	189.81
1030	83.9	993	2.606	30.85	1530	94.7	6205	2.942	192.75
1040	88.2	1081	2.740	33.59	1540	93.8	6299	2.915	195.67
1050	92.8	1174	2.883	36.47	1550	93.0	6392	2.889	198.55
1060	97.2	1271	3.019	39.49	1560	92.2	6484	2.864	201.42
1070	100.8	1372	3.131	42.62	1570	91.4	6575	2.839	204.26
1080	103.4	1475	3.212	45.84	1580	90.6	6666	2.814	207.07
1090	105.1	1581	3.265	49.10	1590	89.8	6756	2.790	209.86
1100	106.0	1687	3.293	52.39	1600	89.1	6845	2.768	212.63
1110	106.6	1793	3.312	55.71	1610	88.4	6933	2.746	215.38
1120	107.1	1900	3.327	59.03	1620	87.8	7021	2.727	218.10
1130	107.5	2008	3.339	62.37	1630	87.1	7108	2.706	220.81
1140	107.9	2116	3.351	65.72	1640	86.5	7195	2.687	223.50
1150	108.2	2224	3.361	69.08	1650	85.9	7280	2.668	226.16
1160	108.5	2332	3.371	72.46	1660	85.3	7366	2.650	228.81
1170	108.7	2441	3.377	75.83	1670	84.6	7450	2.628	231.44
1180	108.9	2550	3.381	79.21	1680	84.0	7534	2.609	234.05
1190	108.9	2659	3.383	82.60	1690	83.3	7618	2.588	236.64
1200	108.9	2768	3.383	85.98	1700	82.7	7700	2.569	239.21
1210	108.9	2877	3.383	89.36	1710	82.1	7782	2.550	241.76
1220	108.9	2986	3.382	92.74	1720	81.5	7864	2.532	244.29
1230	108.8	3094	3.381	96.13	1730	80.8	7945	2.510	246.80
1240	108.8	3203	3.380	99.51	1740	80.2	8025	2.491	249.29
1250	108.7	3312	3.378	102.88	1750	79.6	8105	2.473	251.76
1260	108.6	3420	3.375	106.26	1760	79.0	8184	2.454	254.22
1270	108.5	3529	3.370	109.63	1770	78.4	8262	2.435	256.65
1280	108.3	3637	3.364	112.99	1780	77.8	8340	2.417	259.07
1290	108.1	3745	3.358	116.35	1790	77.2	8417	2.398	261.47
1300	107.9	3853	3.352	119.70	1800	76.6	8494	2.380	263.85
1310	107.7	3961	3.345	123.05	1810	76.1	8570	2.364	266.21
1320	107.4	4068	3.337	126.38	1820	75.5	8645	2.345	268.56
1330	107.1	4175	3.328	129.71	1830	74.9	8720	2.327	270.88
1340	106.8	4282	3.317	133.03	1840	74.3	8794	2.308	273.19
1350	106.4	4389	3.305	136.33	1850	73.7	8868	2.289	275.48
1360	106.0	4495	3.293	139.63	1860	73.1	8941	2.271	277.75
1370	105.6	4600	3.280	142.91	1870	72.6	9014	2.255	280.01
1380	105.1	4705	3.265	146.17	1880	72.0	9086	2.237	282.24
1390	104.6	4810	3.249	149.42	1890	71.5	9157	2.221	284.46
1400	104.0	4914	3.231	152.65	1900	70.9	9228	2.202	286.67

(D) $P_{\varphi} = 3 \tan \varphi + \tan^{3} \varphi$

φ	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0°	.000000	.005236	.010472	.015708	.020945	.026181	.031418	.036656	.041893	.047132
1	.052371	.057610	.062850	.068091	.073333	.078576	.083819	.089064	.094310	.099557
2	.104805	.110054	.115305	.120557	.125811	.131066	.136323	.141581	.146842	.152103
3	.157367	.162633	.167901	.173171	.178442	.183717	.188993	.194272	.199553	.204836
4	.210122	.215411	.220702	.225996	.231293	.236593	.241895	.247201	.252509	.257821
5	.263136	.268454	.273775	.279100	.284428	.289760	.295095	.300434	.305777	.311123
6	.316474	.321828	.327186	.332549	.337915	.343286	.348661	.354040	.359424	.364812
7	.370205	.375602	.381004	.386411	.391823	.397239	.402661	.408088	.413519	.418956
8	.424398	.429846	.435299	.440757	.446222	.451691	.457167	.462648	.468135	.473628
9	.479126	.484631	.490143	.495660	.501184	.506714	.512251	.517794	.523344	.528900
10	.534463	.540033	.545610	.551194	.556785	.562384	.567989	.573602	.579222	.584850
11	.590485	.596128	.601779	.607438	.613104	.618778	.624461	.630151	.635850	.641558
12	.647273	.652997	.658730	.664471	.670221	.675980	.681748	.687525	.693310	.699105
13	.704910	.710724	.716547	.722380	.728222	.734074	.739936	.745808	.751690	.757581
14	.763483	.769396	.775319	.781252	.787196	.793150	.799115	.805091	.811078	.817076
15	.823086	.829106	.835138	.841181	.847236	.853302	.859381	.865471	.871573	.877687
16	.883813	.889952	.896103	.902266	.908442	.914631	.920832	.927047	.933275	.939515
17	.945769	.952036	.958317	.964611	.970919	.977241	.983577	.989927	.996291	1.002669
18	1.009062	1.015469	1.021891	1.028327	1.034779	1.041245	1.047727	1.054224	1.060736	1.067263
19	1.073807	1.080366	1.086941	1.093532	1.100139	1.106762	1.113402	1.120058	1.126731	1.133421
20	1.140127	1.146851	1.153592	1.160350	1.167126	1.173919	1.180730	1.187559	1.194407	1.201272

(E) TABLE OF VALUES OF [v versin φ].

V f - s	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	V f - s
100	0.02	0.06	0.14	0.24	0.38	0.55	0.75	0.97	1.23	1.52	1.84	2.19	2.56	2.97	3.41	3.87	4.37	4.89	100
200	0.03	0.12	0.27	0.49	0.76	1.10	1.49	1.95	2.46	3.04	3.67	4.37	5.13	5.94	6.81	7.75	8.74	9.79	200
300	0.05	0.18	0.41	0.73	1.14	1.64	2.24	2.92	3.69	4.56	5.51	6.56	7.69	8.91	10.22	11.62	13.11	14.68	300
400	0.06	0.24	0.55	0.97	1.52	2.19	2.98	3.89	4.92	6.08	7.35	8.74	10.25	11.88	13.63	15.50	17.48	19.58	400
500	0.08	0.30	0.69	1.22	1.90	2.74	3.73	4.87	6.16	7.60	9.19	10.93	12.81	14.85	17.04	19.37	21.85	24.47	500
600	0.09	0.37	0.82	1.46	2.28	3.29	4.47	5.84	7.39	9.12	11.02	13.11	15.38	17.82	20.44	23.24	26.22	29.37	600
700	0.11	0.43	0.96	1.71	2.66	3.83	5.22	6.82	8.62	10.63	12.86	15.30	17.94	20.79	23.85	27.12	30.59	34.26	700
800	0.12	0.49	1.10	1.95	3.04	4.38	5.96	7.79	9.85	12.15	14.70	17.48	20.50	23.76	27.26	30.99	34.96	39.15	800
900	0.14	0.55	1.23	2.19	3.42	4.93	6.71	8.76	11.08	13.67	16.54	19.67	23.07	26.73	30.67	34.86	39.33	44.05	900
1000	0.15	0.61	1.37	2.44	3.81	5.48	7.45	9.73	12.31	15.19	18.37	21.85	25.63	29.70	34.07	38.74	43.70	48.94	1000
1100	0.17	0.67	1.51	2.68	4.19	6.03	8.20	10.71	13.54	16.71	20.21	24.04	28.19	32.67	37.48	42.61	48.06	53.84	1100
1200	0.18	0.73	1.64	2.92	4.57	6.57	8.94	11.68	14.77	18.23	22.05	26.22	30.76	35.65	40.89	46.49	52.43	58.73	1200
1300	0.20	0.79	1.78	3.17	4.95	7.12	9.69	12.65	16.01	19.75	23.88	28.41	33.32	38.62	44.30	50.36	56.80	63.63	1300
1400	0.21	0.85	1.92	3.41	5.33	7.67	10.44	13.62	17.24	21.27	25.72	30.59	35.88	41.59	47.70	54.23	61.17	68.52	1400
1500	0.23	0.91	2.06	3.65	5.71	8.22	11.18	14.60	18.47	22.79	27.56	32.78	38.44	44.56	51.11	58.11	65.54	73.42	1500
1600	0.24	0.97	2.19	3.90	6.09	8.76	11.93	15.57	19.70	24.31	29.40	34.96	41.01	47.53	54.52	61.98	69.91	78.31	1600
1700	0.26	1.04	2.33	4.14	6.47	9.31	12.67	16.54	20.93	25.83	31.23	37.15	43.57	50.50	57.93	65.86	74.28	83.20	1700
1800	0.27	1.10	2.47	4.38	6.85	9.86	13.42	17.52	22.16	27.35	33.07	39.33	46.13	53.47	61.33	69.73	78.65	88.10	1800
1900	0.29	1.16	2.60	4.63	7.23	10.41	14.16	18.49	23.39	28.87	34.91	41.52	48.70	56.44	64.74	73.60	83.02	92.99	1900
2000	0.30	1.22	2.74	4.87	7.61	10.96	14.91	19.46	24.62	30.38	36.75	43.70	51.26	59.41	68.15	77.48	87.39	97.89	2000
2100	0.32	1.28	2.88	5.12	7.99	11.50	15.65	20.44	25.85	31.90	38.58	45.89	53.82	62.38	71.56	81.35	91.76	102.8	2100
2200	0.34	1.34	3.02	5.36	8.37	12.05	16.40	21.41	27.09	33.42	40.42	48.08	56.39	65.35	74.96	85.22	96.13	107.7	2200
2300	0.35	1.40	3.15	5.60	8.75	12.60	17.14	22.38	28.32	34.94	42.26	50.26	58.95	68.32	78.37	89.10	100.5	112.6	2300
2400	0.37	1.46	3.29	5.85	9.13	13.15	17.89	23.36	29.55	36.46	44.09	52.45	61.51	71.29	81.78	92.97	104.9	117.5	2400

(F) TABLE OF VALUES OF $[1000 \div v]^3$

V f - s	0	1	2	3	4	5	6	7	8	9
500	8.0000	*9522	*9048	*8577	*8110	*7647	*7188	*6732	*6280	*5831
510	7.5386	4944	4506	4071	3639	3211	2787	2365	1947	1532
520	7.1120	0711	0305	*9903	*9503	*9107	*8714	*8323	*7936	*7551
530	6.7170	6791	6415	6042	5671	5304	4939	4577	4217	3861
540	6.3507	3155	2806	2459	2116	1775	1436	1100	0766	0434
550	6.0105	*9779	*9454	*9132	*8813	*8495	*8180	*7867	*7557	*7249
560	5.6942	6638	6337	6037	5739	5444	5151	4859	4570	4283
570	5.3998	3715	3433	3154	2877	2601	2328	2056	1786	1519
580	5.1253	0988	0726	0465	0207	*9950	*9694	*9441	*9189	*8939
590	4.8690	8444	8199	7955	7713	7473	7235	6998	6762	6529
600	4.6296	6066	5836	5609	5383	5158	4935	4713	4493	4274
610	4.4057	3841	3626	3413	3201	2991	2782	2574	2368	2163
620	4.1959	1757	1556	1356	1157	0960	0764	0569	0376	0184
630	3.9992	9803	9614	9427	9240	9055	8871	8688	8507	8326
640	3.8147	7969	7792	7616	7441	7267	7094	6922	6751	6582
650	3.6413	6246	6079	5914	5749	5586	5423	5262	5101	4942
660	3.4783	4625	4469	4313	4158	4004	3851	3699	3548	3398
670	3.3249	3100	2953	2806	2660	2515	2371	2228	2086	1944
680	3.1803	1663	1524	1386	1249	1112	0976	0841	0707	0573
690	3.0441	0309	0177	0047	*9917	*9788	*9660	*9533	*9406	*9280
700	2.9155	9030	8906	8783	8660	8539	8418	8297	8177	8058
710	2.7 9399	8222	7051	5887	4730	3578	2434	1295	0163	*9038
720	2.6 7918	6805	5698	4597	3502	2413	1331	0254	*9183	*8118
730	2.5 7058	6005	4957	3915	2879	1848	0823	*9803	*8789	*7780
740	2.4 6777	5779	4787	3800	2818	1842	0870	*9904	*8943	*7988
750	2.3 7037	6092	5151	4215	3285	2359	1438	0522	*9611	*8704
760	2.2 7803	6906	6014	5126	4244	3365	2492	1623	0758	*9898
770	2.1 9042	8191	7344	6502	5664	4830	4001	3175	2354	1538
780	2.1 0725	*9917	*9112	*8312	*7516	*6724	*5936	*5152	*4372	*3596
790	2.0 2824	2056	1291	0531	*9774	*9021	*8272	*7526	*6785	*6047
800	1.9 5313	4582	3855	3132	2412	1696	0983	0274	*9568	*8866
810	1.8 8168	7473	6781	6092	5407	4726	4047	3372	2701	2032
820	1.8 1367	0705	0047	*9391	*8739	*8089	*7443	*6801	*6161	*5524
830	1.7 4890	4260	3632	3008	2386	1767	1152	0539	*9929	*9322
840	1.6 8718	8117	7519	6924	6331	5741	5154	4570	3988	3409
850	1.6 2833	2260	1689	1121	0556	*9993	*9433	*8876	*8321	*7769
860	1.5 7219	6672	6127	5585	5045	4508	3974	3441	2912	2385
870	1.5 1860	1337	0817	0299	*9784	*9271	*8761	*8252	*7746	*7243
880	1.4 6741	6242	5745	5251	4758	4268	3780	3294	2811	2329
890	1.4 1850	1373	0898	0425	*9955	*9486	*9020	*8555	*8093	*7633
900	1.3 7174	6718	6264	5812	5361	4913	4467	4022	3580	3140
910	1.3 2702	2265	1830	1398	0967	0538	0111	*9686	*9262	*8841
920	1.2 8421	8003	7587	7173	6761	6350	5941	5534	5128	4725
930	1.2 4323	3923	3524	3127	2732	2339	1947	1557	1169	0782
940	1.2 0397	0014	*9632	*9252	*8873	*8496	*8121	*7747	*7375	*7004
950	1.1 6635	6268	5902	5537	5174	4813	4454	4095	3738	3382
960	1.1 3028	2676	2325	1975	1627	1280	0935	0591	0249	*9908
970	1.0 9568	9230	8893	8558	8224	7891	7560	7230	6902	6574

V f - s	0	1	2	3	4	5	6	7	8	9
980	1,0 6248	5924	5600	5278	4958	4638	4320	4004	3688	3374
990	1,0 3061	2749	2439	2130	1822	1515	1210	0905	0602	0301
1000	1,0 0000	*9701	*9402	*9105	*8810	*8515	*8221	*7929	*7638	*7348
1010	0,9 7059	6771	6485	6199	5916	5632	5350	5069	4789	4510
1020	0,9 4232	3956	3680	3406	3132	2860	2589	2319	2050	1781
1030	0.9 1514	1249	0983	0719	0456	0194	*9934	*9673	*9414	*9157
1040	0,8 8900	8644	8388	8135	7882	7630	7378	7128	6879	6631
1050	0.8 6383	6137	5892	5648	5404	5161	4920	4679	4439	4200
1060	0.8 3962	3725	3488	3253	3019	2785	2552	2320	2089	1859
1070	0.8 1630	1401	1174	0947	0721	0496	0272	0049	*9826	*9604
1080	0.7 9383	9164	8944	8725	8508	8291	8075	7859	7645	7431
1090	0.7 7218	7006	6795	6584	6374	6165	5957	5750	5543	5337
1100	0.7 5131	4927	4723	4520	4318	4116	3915	3715	3516	3317
1110	0.7 3119	2922	2725	2529	2334	2140	1946	1753	1561	1369
1120	0.7 1178	0988	0798	0609	0421	0233	0046	*9860	*9674	*9489
1130	0.6 9305	9121	8938	8756	8574	8393	8213	8033	7854	7675
1140	0.6 7497	7320	7143	6967	6791	6617	6443	6269	6096	5923
1150	0.6 5752	5580	5410	5240	5070	4901	4733	4565	4398	4232
1160	0.6 4066	3900	3736	3571	3408	3244	3082	2920	2758	2597
1170	0.6 2437	2277	2118	1959	1801	1643	1486	1330	1173	1018
1180	0.6 0863	0709	0555	0401	0248	0096	*9944	*9793	*9642	*9491
1190	0.5 9342	9192	9043	8895	8747	8600	8453	8307	8161	8015
1200	0.5 7870	7726	7582	7439	7296	7153	7011	6869	6728	6587
1210	0.5 6447	6308	6168	6030	5891	5753	5616	5479	5342	5206
1220	0.5 5071	4935	4801	4666	4532	4399	4266	4134	4001	3870
1230	0.5 3738	3607	3477	3347	3218	3088	2960	2831	2703	2576
1240	0.5 2449	2322	2196	2070	1944	1819	1695	1570	1447	1323
1250	0.5 1200	1077	0955	0833	0712	0591	0470	0349	0229	0110
1260	0.4 9990	9872	9753	9635	9518	9400	9283	9167	9050	8934
1270	0.4 8819	8704	8589	8475	8361	8247	8134	8021	7908	7796
1280	0.4 7684	7572	7461	7350	7239	7129	7019	6910	6801	6692
1290	0.4 6583	6475	6367	6260	6153	6046	5939	5833	5727	5622
1300	0.4 5517	5412	5307	5203	5099	4995	4892	4789	4687	4584
1310	0.4 4482	4380	4279	4178	4077	3977	3877	3777	3677	3578
1320	0.4 3479	3380	3282	3184	3086	2989	2891	2794	2698	2601
1330	0.4 2505	2409	2314	2219	2124	2030	1935	1841	1748	1654
1340	0.4 1561	1468	1375	1283	1191	1099	1008	0916	0825	0735
1350	0.4 0644	0554	0464	0374	0285	0196	0107	0018	*9930	*9842
1360	0.3 9754	9667	9579	9492	9405	9319	9233	9147	9061	8975
1370	0.3 8890	8805	8720	8636	8551	8467	8383	8300	8217	8134
1380	0.3 8051	7968	7886	7804	7722	7640	7559	7478	7397	7316
1390	0.3 7235	7155	7075	6995	6916	6836	6757	6678	6600	6521
1400	0.3 6443	6365	6287	6210	6133	6055	5979	5902	5825	5749
1410	0.3 5673	5597	5522	5447	5371	5296	5222	5147	5073	4999
1420	0.3 4925	4851	4778	4704	4631	4559	4486	4413	4341	4269
1430	0.3 4197	4126	4054	3983	3912	3841	3770	3700	3630	3560
1440	0.3 3490	3420	3351	3281	3212	3143	3075	3006	2938	2870
1450	0.3 2802	2734	2666	2599	2532	2465	2398	2331	2265	2198
1460	0.3 2132	2066	2001	1935	1870	1804	1739	1674	1610	1545
1470	0.3 1481	1417	1353	1289	1225	1162	1099	1035	0973	0910
1480	0.3 0847	0785	0722	0660	0598	0537	0475	0414	0352	0291

V f - s	0	1	2	3	4	5	6	7	8	9
1490	0.3 0230	0169	0109	0048	*9988	*9928	*9868	*9808	*9748	*9689
1500	0.2 9630	9570	9511	9452	9394	9335	9277	9219	9161	9103
1510	0.2 9045	8987	8930	8872	8815	8758	8701	8645	8588	8532
1520	0.2 8475	8419	8363	8307	8252	8196	8141	8086	8030	7975
1530	0.2 7921	7866	7811	7757	7703	7649	7595	7541	7487	7434
1540	0.2 7380	7327	7274	7221	7168	7115	7063	7010	6958	6906
1550	0.2 6854	6802	6750	6698	6647	6596	6544	6493	6442	6391
1560	0.2 6341	6290	6240	6189	6139	6089	6039	5989	5940	5890
1570	0.2 5841	5791	5742	5693	5644	5595	5547	5498	5449	5401
1580	0.2 5353	5305	5257	5209	5161	5114	5066	5019	4972	4925
1590	0.2 4878	4831	4784	4737	4691	4644	4598	4552	4506	4460
1600	0.2 4414	4368	4323	4277	4232	4187	4141	4096	4051	4007
1610	0.2 3962	3917	3873	3828	3784	3740	3696	3652	3608	3565
1620	0.2 3521	3477	3434	3391	3348	3305	3262	3219	3176	3133
1630	0.2 3091	3048	3006	2964	2922	2880	2838	2796	2754	2712
1640	0.2 2671	2629	2588	2547	2506	2465	2424	2383	2342	2302
1650	0.2 2261	2221	2180	2140	2100	2060	2020	1980	1941	1901
1660	0.2 1861	1822	1782	1743	1704	1665	1626	1587	1548	1510
1670	0.2 1471	1432	1394	1356	1317	1279	1241	1203	1165	1127
1680	0.2 1090	1052	1015	0977	0940	0903	0865	0828	0791	0754
1690	0.2 0718	0681	0644	0608	0571	0535	0499	0462	0426	0390
1700	0.2 0354	0318	0282	0247	0211	0176	0140	0105	0069	0034
1710	0.1 9999	9964	9929	9894	9859	9825	9790	9756	9721	9687
1720	0.1 9652	9618	9584	9550	9516	9482	9448	9414	9381	9347
1730	0.1 9314	9280	9247	9213	9180	9147	9114	9081	9048	9015
1740	0.1 8982	8950	8917	8885	8852	8820	8787	8755	8723	8691
1750	0.1 8659	8627	8595	8563	8532	8500	8468	8437	8405	8374
1760	0.1 8343	8311	8280	8249	8218	8187	8156	8126	8095	8064
1770	0.1 8034	8003	7973	7942	7912	7882	7851	7821	7791	7761
1780	0.1 7731	7701	7672	7642	7612	7583	7553	7524	7494	7465
1790	0.1 7436	7407	7377	7348	7319	7290	7262	7233	7204	7175
1800	0.1 7147	7118	7090	7061	7033	7005	6976	6948	6920	6892
1810	0.1 6864	6836	6808	6781	6753	6725	6698	6670	6642	6615
1820	0.1 6588	6560	6533	6506	6479	6452	6425	6398	6371	6344
1830	0.1 6317	6291	6264	6237	6211	6184	6158	6131	6105	6079
1840	0.1 6053	6026	6000	5974	5948	5922	5897	5871	5845	5819
1850	0.1 5794	5768	5743	5717	5692	5666	5641	5616	5591	5565
1860	0.1 5540	5515	5490	5465	5441	5416	5391	5366	5342	5317
1870	0.1 5292	5268	5243	5219	5195	5170	5146	5122	5098	5074
1880	0.1 5050	5026	5002	4978	4954	4930	4906	4883	4859	4836
1890	0.1 4812	4789	4765	4742	4718	4695	4672	4649	4626	4602
1900	0.1 4579	4556	4533	4511	4488	4465	4442	4419	4397	4374
1910	0.1 4352	4329	4307	4284	4262	4239	4217	4195	4173	4151
1920	0.1 4129	4106	4084	4062	4041	4019	3997	3975	3953	3932
1930	0.1 3910	3888	3867	3845	3824	3802	3781	3760	3738	3717
1940	0.1 3696	3675	3654	3633	3612	3591	3570	3549	3528	3507
1950	0.1 3486	3466	3445	3424	3404	3383	3363	3342	3322	3301
1960	0.1 3281	3261	3240	3220	3200	3180	3160	3140	3120	3100
1970	0.1 3080	3060	3040	3020	3000	2981	2961	2941	2922	2902
1980	0.1 2883	2863	2844	2824	2805	2786	2766	2747	2728	2709
1990	0.1 2689	2670	2651	2632	2613	2594	2575	2556	2538	2519

(G) TABLE OF VALUES OF
$h = {}^1/_2\, gt^2 = 16.0954\, t^2$ FEET.

t	.000	.001	.002	.003	.004	.005	.006	.007	008.	.009
″	Eeet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0.00	0.000	.000	.000	.000	.000	.000	.001	.001	.001	.001
0.01	.002	.002	.002	.003	.003	.004	.004	.005	.005	.006
0.02	.006	.007	.008	.009	.009	.010	.011	.012	.013	.014
0.03	.014	.015	.016	.018	.019	.020	.021	.022	.023	.024
0.04	.026	.027	.028	.030	.031	.033	.034	.036	.037	.039
0.05	.040	.042	.044	.045	.047	.049	.050	.052	.054	.056
0.06	.058	.060	.062	.064	.066	.068	.070	.072	.074	.077
0.07	.079	.081	.083	.086	.088	.091	.093	.095	.098	.100
0.08	.103	.106	.108	.111	.114	.116	.119	.122	.125	.127
0.09	.130	.133	.136	.139	.142	.145	.148	.151	.155	.158
0.10	.161	.164	.167	.171	.174	.177	.181	.184	.188	.191
0.11	.195	.198	.202	.206	.209	.213	.217	.220	.224	.228
0.12	.232	.236	.240	.244	.247	.251	.256	.260	.264	.268
0.13	.272	.276	.280	.285	.289	.293	.298	.302	.307	.311
0.14	.315	.320	.325	.329	.334	.338	.343	.348	.353	.357
0.15	.362	.367	.372	.377	.382	.387	.392	.397	.402	.407
0.16	.412	.417	.422	.428	.433	.438	.444	.449	.454	.460
0.17	.465	.471	.476	.482	.487	.493	.499	.504	.510	.516
0.18	.521	.527	.533	.539	.545	.551	.557	.563	.569	.575
0.19	.581	.587	.593	.600	.606	.612	.618	.625	.631	.637
0.20	.644	.650	.657	.663	.670	.676	.683	.690	.696	.703
0.21	.710	.717	.723	.730	.737	.744	.751	.758	.765	.772
0.22	.779	.786	.793	.800	.808	.815	.822	.829	.837	.844
0.23	.851	.859	.866	.874	.881	.889	.896	.904	.912	.919
0.24	0.927	.935	.943	.950	.958	.966	.974	.982	.990	.998
0.25	1.006	.014	.022	.030	.038	.047	.055	.063	.071	.080
0.26	.088	.096	.105	.113	.122	.130	.139	.147	.156	.165
0.27	.173	.182	.191	.200	.208	.217	.226	.235	.244	.253
0.28	.262	.271	.280	.289	.298	.307	.317	.326	.335	.344
0.29	.354	.363	.372	.382	.391	.401	.410	.420	.429	.439
0.30	.449	.458	.468	.478	.487	.497	.507	.517	.527	.537
0.31	.547	.557	.567	.577	.587	.597	.607	.617	.628	.638
0.32	.648	.658	.669	.679	.690	.700	.711	.721	.732	.742
0.33	.753	.763	.774	.785	.796	.806	.817	.828	.839	.850
0.34	.861	.872	.883	.894	.905	.916	.927	.938	.949	.960
0.35	1.972	.983	.994	*.006	*.017	*.028	*.040	*.051	*.063	*.074
0.36	2.086	.098	.109	.121	.133	.144	.156	.168	.180	.192
0.37	.203	.215	.227	.239	.251	.263	.276	.288	.300	.312
0.38	.324	.336	.349	.361	.373	.386	.398	.411	.423	.436
0.39	.448	.461	.473	.486	.499	.511	.524	.537	.550	.562
0.40	.575	.588	.601	.614	.627	.640	.653	.666	.679	.692
0.41	.706	.719	.732	.745	.759	.772	.785	.799	.812	.826
0.42	.839	.853	.866	.880	.894	.907	.921	.935	.948	.962
0.43	2.976	.990	*.004	*.018	*.032	*.046	*.060	*.074	*.088	*.102
0.44	3.116	.130	.144	.159	.173	.187	.202	.216	.230	.245
0.45	.259	.273	.288	.303	.318	.332	.347	.362	.376	.391
0.46	.406	.421	.435	.450	.465	.480	.495	.510	.525	.540
0.47	.555	.571	.586	.601	.616	.632	.647	.662	.678	.693
0.48	.708	.724	.739	.755	.770	.786	.802	.817	.833	.849
0.49	3.865	.880	.896	.912	.928	.944	.960	.976	.992	*.008
0.50	4.024	.040	.056	.072	.088	.105	.121	.137	.154	.170

t	.000	.001	.002	.003	.004	.005	.006	.007	.008	.009
″	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0.50	4.024	.040	.056	.072	.088	.105	.121	.137	.154	.170
0.51	.186	.203	.219	.236	.252	.269	.285	.302	.319	.335
0.52	.352	.369	.386	.403	.419	.436	.453	.470	.487	.504
0.53	.521	.538	.555	.573	.590	.607	.624	.641	.659	.676
0.54	.693	.711	.728	.746	.763	.781	.798	.816	.833	.851
0.55	4.869	.887	.904	.922	.940	.958	.976	.994	*.012	*.030
0.56	5.048	.066	.084	.102	.120	.138	.156	.174	.193	.211
0.57	.229	.248	.266	.285	.303	.322	.340	.359	.377	.396
0.58	.414	.433	.452	.471	.489	.508	.527	.546	.565	.584
0.59	.603	.622	.641	.660	679	.698	.717	.737	.756	.775
0.60	.794	.814	.833	.852	872	.891	.911	.930	.950	.969
0.61	5.989	*.009	*.028	*.048	*.068	*.088	*.107	*.127	*.147	*.167
0.62	6.187	.207	.227	.247	.267	.287	.307	.328	.348	.368
0.63	.388	.409	.429	.449	.470	.490	.511	.531	.352	.372
0.64	.593	.613	.634	.655	.675	.696	.717	.738	.759	.779
0.65	6.800	.821	.842	.863	.884	.905	.926	.948	.969	.990
0.66	7.011	.032	.054	.075	.096	.118	.139	.161	.182	.204
0.67	.225	.247	.268	.290	.312	.333	.355	.377	.399	.421
0.68	.443	.464	.486	.508	.530	.552	.574	.597	.619	.641
0.69	.663	.685	.708	.730	.752	.774	.797	.819	.842	.864
0.70	7.887	.909	.932	.954	.977	*.000	*.023	*.045	*.068	*.091
0.71	8.114	.137	.159	.182	.205	.228	.251	.274	.298	.321
0.72	.344	.367	.390	.414	.437	.460	.484	.507	.530	.354
0.73	.577	.601	.624	.648	.671	.695	.719	.743	.766	.790
0.74	8.814	.838	.862	.885	.909	.933	.957	.981	*.005	*.030
0.75	9.054	.078	.102	.126	.150	.175	.199	.223	.248	.272
0.76	.297	.321	.346	.370	.395	.419	.444	.469	.493	.518
0.77	.543	.568	.593	.617	.642	.667	.692	.717	.742	.767
0.78	9.792	.818	.843	.868	.893	.918	.944	.969	.994	*.020
0.79	10.045	.071	.096	.122	.147	.173	.198	.224	.250	.275
0.80	.301	.327	.353	.378	.404	.430	.456	.482	.508	.534
0.81	.560	.586	.612	.639	.665	.691	.717	.744	.770	.796
0.82	10.823	.849	.875	.902	.928	.955	.982	*.008	*.035	*.061
0.83	11.088	.115	.142	.168	.195	.222	.249	.276	.303	.330
0.84	.357	.384	.411	.438	.465	.493	.520	.547	.574	.602
0.85	.629	.656	.684	.711	.739	.766	.794	.821	.849	.876
0.86	11.904	.932	.960	.987	*.015	*.043	*.071	*.099	*.127	*.155
0.87	12.183	.211	.239	.267	.295	.323	.351	.379	.408	.436
0.88	.464	.493	.521	.549	.578	.606	.635	.663	.692	.721
0.89	12.749	.778	.807	.835	.864	.893	.922	.951	.979	*.008
0.90	13.037	.066	.095	.124	.153	.183	.212	.241	.270	.299
0.91	.329	.358	.387	.417	.446	.475	.505	.534	.564	.594
0.92	.623	.653	.682	.712	.742	.772	.801	.831	.861	.891
0.93	13.921	.951	.981	*.011	*.041	*.071	*.101	*.131	*.161	*.192
0.94	14.222	.252	.282	.313	.343	.374	.404	.435	.465	.496
0.95	.526	.557	.587	.618	.649	.679	.710	.741	.772	.803
0.96	14.834	.864	.895	.926	.957	.988	*.020	*.051	*.082	*.113
0.97	15.144	.175	.207	.238	.269	.301	.332	.364	.395	.426
0.98	.458	.490	.521	.553	.584	.616	.648	.680	.711	.743
0.99	15.775	.807	.839	.871	.903	.935	.967	.999	*.031	*.063
1.00	16,095	.128	.160	.192	.224	.257	.289	.322	.354	.386

t	,000	.001	,002	,003	,004	,005	,006	.007	.008	009.
″	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
1,00	16,095	,128	,160	,192	.224	.257	.289	.322	.354	.386
1,01	16.419	.451	.484	.517	.549	.582	.615	.647	.680	.713
1.02	16.746	.779	.811	.844	.877	.910	.943	.976	*,009	*.042
1,03	17,076	.109	.142	.175	.208	.242	.275	.308	.342	.375
1,04	17.409	.442	.476	.509	.543	.577	.610	.644	.678	.711
1,05	17.745	.779	.813	.847	.881	.915	.949	.983	*.017	*.051
1,06	18,085	,118	,153	.187	.222	.256	.290	.324	.359	.393
1,07	18.428	.462	.497	.531	.566	.600	.635	.670	.704	.739
1,08	18.774	.808	.843	.878	.913	.948	.983	*.018	*.053	*.088
1.09	19.123	.158	.193	.228	.264	.299	.334	.369	.405	.440
1.10	19.475	.511	.546	.582	.617	.653	.688	.724	.760	.795
1,11	19.831	.867	.903	.938	.974	*,010	*,046	*,082	*.118	*.154
1,12	20,190	.226	.262	.298	.335	.371	.407	.443	.480	.516
1,13	20.552	.589	.625	.661	,698	.734	.771	.808	.844	.881
1,14	20.918	.954	.991	*.028	*,065	*.101	*.138	*.175	*.212	*.249
1,15	21.286	.323	.360	.397	.435	.472	.509	.546	.583	.621
1,16	21,658	.695	.733	.770	.808	.845	.883	.920	.958	.995
1,17	22.033	.071	.108	.146	.184	.222	.260	.297	.335	.373
1,18	22.411	.449	.487	.425	.563	.602	.640	.678	.716	.754
1,19	22.793	.831	.869	.908	.946	.985	*.023	*.062	*.100	*.139
1.20	23.177	.216	.255	.293	.332	.371	.410	.449	.487	.526
1,21	23.565	.604	.643	.682	.721	.760	.800	.839	.878	.917
1.22	23.956	.996	*.035	*.074	*.114	*.153	*.193	*.232	*.272	*.311
1.23	24.351	.390	.430	.470	.509	.549	.589	.629	.669	.708
1.24	24.748	.788	.828	.868	.908	.948	.988	*,028	*.069	*.109
1.25	25.149	.189	.230	.270	.310	.351	.391	.432	.472	.513
1,26	25.553	.594	.634	.675	.716	.756	.797	.838	.879	.919
1.27	25.960	*.001	*.042	*,083	*.124	*.165	*.206	*.247	*.288	*.330
1,28	26.371	.412	.453	.494	.536	.577	.619	.660	.701	.743
1.29	26.784	.826	.867	.909	.951	.992	*.034	*.076	*.118	*.159
1.30	27.201	.243	.285	.327	.369	.411	.453	.495	.537	.579
1.31	27.621	.664	.706	.748	.790	.833	.875	.917	.960	*.002
1.32	28.045	.087	.130	.172	.215	.257	.300	.343	.386	.428
1.33	28.471	.514	.557	.600	.643	.686	.729	.772	.815	.858
1.34	28.901	.944	.987	*.030	*.074	*.117	*.160	*.204	*.247	*.290
1.35	29.334	.377	.421	.464	.508	.552	.595	.639	.683	.726
1.36	29.770	.714	.858	.902	.945	.989	*.033	*.077	*.121	*.165
1.37	30.209	.254	.298	.342	.386	.430	.475	.519	.563	.608
1.38	30.652	.697	.741	.785	.830	.875	.919	.964	*.008	*.053
1.39	31.098	.143	.187	.232	.277	.322	.367	.412	.457	.502
1.40	31.547	.592	.637	.682	.728	.773	.818	.863	.909	.954
1.41	31.999	*.045	*.090	*.136	*.181	*.227	*.272	*.318	*.363	*.409
1.42	32.455	.500	.546	.592	.638	.684	.730	.776	.821	.867
1.43	32.913	.960	*.006	*.052	*.098	*.144	*.190	*.237	*.283	*.329
1.44	33.375	.422	.468	.515	.561	.608	.654	.701	.747	.794
1.45	33.841	.887	.934	.981	*.028	*.074	*.121	*.168	*.215	*.262
1.46	34.309	.356	.403	.450	.497	.544	.592	.639	.686	.733
1.47	34.781	.828	.875	.923	.970	*.018	*.065	*.113	*.160	*.208
1.48	35.255	.303	.351	.398	.446	.494	.542	.590	.638	.685
1.49	35.733	.781	.829	.877	.926	.974	*.022	*.070	*.118	*.166
1.50	*36.215*	*.263*	.311	.360	.408	.456	.505	.553	.602	.651

(H) COEFFICIENTS FOR THE CUBIC LAW OF RESISTANCE.
PROJECTILES WITH OGIVAL-HEADS.

V f-s	K_v	$\frac{K_v}{g}$	Log $\frac{K_v}{g}$	$\Sigma\frac{K_v}{g}$	V f-s	K_v	$\frac{K_v}{g}$	Log $\frac{K_v}{g}$	$\Sigma\frac{K_v}{g}$
100	578.1	17.959	1.2543	0	520	117.3	3.644	.5616	298.53
110	525.5	16.325	1.2129	17.10	530	115.0	3.573	.5530	302.14
120	481.7	14.964	1.1750	32.72	540	112.8	3.504	.5446	305.68
130	444.7	13.815	1.1404	47.08	550	110.7	3.439	.5364	309.15
140	412.9	12.827	1.1081	60.39	560	108.7	3.377	.5285	312.56
150	385.4	11.972	1.0782	72.77	570	106.7	3.315	.5205	315.90
160	361.3	11.224	1.0501	84.36	580	104.6	3.249	.5118	319.19
170	340.1	10.565	1.0239	95.24	590	102.5	3.184	.5030	322.40
180	321.2	9.978	.9990	105.51	600	100.5	3.122	.4944	325.56
190	304.3	9.453	.9756	115.21	610	98.6	3.063	.4862	328.65
200	289.0	8.978	.9532	124.42	620	96.8	3.007	.4781	331.68
210	275.3	8.552	.9321	133.18	630	95.1	2.954	.4704	334.66
220	262.8	8.164	.9119	141.54	640	93.5	2.905	.4632	337.59
230	251.3	7.807	.8925	149.52	650	91.9	2.855	.4556	340.47
240	240.9	7.484	.8741	157.16	660	90.5	2.811	.4489	343.30
250	231.3	7.182	.8563	164.49	670	89.1	2.768	.4422	346.09
260	222.4	6.909	.8394	171.53	680	87.7	2.724	.4352	348.84
270	214.2	6.651	.8229	178.31	690	86.3	2.681	.4283	351.54
280	206.5	6.415	.8072	184.84	700	84.9	2.637	.4211	354.20
290	199.3	6.191	.7918	191.14	710	83.7	2.600	.4150	356.82
300	192.7	5.986	.7771	197.23	720	82.6	2.566	.4093	359.40
310	186.5	5.794	.7630	203.12	730	81.6	2.535	.4040	361.95
320	180.8	5.617	.7495	208.82	740	80.6	2.504	.3986	364.47
330	175.5	5.452	.7366	214.35	750	79.6	2.473	.3932	366.96
340	170.6	5.299	.7242	219.73	760	78.7	2.445	.3883	369.42
350	166.0	5.158	.7125	224.96	770	78.0	2.423	.3844	371.85
360	161.9	5.029	.7015	230.05	780	77.4	2.404	.3809	374.26
370	158.0	4.907	.6908	235.01	790	76.8	2.386	.3777	376.66
380	154.4	4.795	.6808	239.86	800	76.2	2.367	.3742	379.03
390	151.1	4.693	.6715	244.61	810	75.6	2.348	.3707	381.39
400	148.0	4.599	.6627	249.25	820	75.2	2.336	.3685	383.73
410	145.2	4.512	.6544	253.81	830	75.1	2.333	.3679	386.07
420	142.5	4.427	.6461	258.28	840	75.0	2.330	.3674	388.40
430	139.8	4.343	.6378	262.66	850	75.0	2.330	.3674	390.73
440	137.2	4.262	.6296	266.96	860	75.0	2.330	.3674	393.06
450	134.6	4.181	.6213	271.19	870	75.0	2.330	.3674	395.39
460	132.0	4.101	.6129	275.33	880	75.0	2.330	.3674	397.72
470	129.4	4.020	.6042	279.39	890	75.0	2.330	.3674	400.05
480	126.9	3.942	.5957	283.37	900	75.0	2.330	.3674	402.38
490	124.4	3.865	.5872	287.28	910	75.0	2.330	.3674	404.71
500	121.9	3.787	.5783	291.10	920	75.0	2.330	.3674	407.04
510	119.6	3.715	.5700	294.85	930	75.0	2.330	.3674	409.37

(H) COEFFICIENTS FOR THE CUBIC LAW OF RESISTANCE.

V f-s	K_v	$\frac{K_v}{g}$	$\text{Log}\frac{K_v}{g}$	$\Sigma\frac{K_v}{g}$	V f-s	K_v	$\frac{K_v}{g}$	$\text{Log}\frac{K_v}{g}$	$\Sigma\frac{K_v}{g}$
940	75.0	2.330	.3674	411.70	1420	103.5	3.215	.5072	560.81
950	75.0	2.330	.3674	414.03	1430	102.9	3.197	.5047	564.01
960	75.0	2.330	.3674	416.36	1440	102.3	3.178	.5022	567.20
970	75.0	2.330	.3674	418.69	1450	101.6	3.156	.4991	570.37
980	75.0	2.330	.3674	421.02	1460	100.9	3.134	.4961	573.51
990	75.0	2.330	.3674	423.35	1470	100.1	3.110	.4928	576.63
1000	75.0	2.330	.3674	425.68	1480	99.4	3.088	.4897	579.73
1010	75.1	2.333	.3679	428.01	1490	98.6	3.063	.4862	582.80
1020	75.3	2.339	.3690	430.34	1500	97.9	3.041	.4830	585.86
1030	76.7	2.383	.3771	432.69	1510	97.1	3.016	.4794	588.89
1040	80.8	2.510	.3997	435.13	1520	96.2	2.988	.4754	591.89
1050	87.3	2.712	.4333	437.73	1530	95.3	2.960	.4713	594.86
1060	94.0	2.920	.4654	440.55	1540	94.4	2.933	.4673	597.81
1070	98.7	3.066	.4866	443.55	1550	93.6	2.908	.4636	600.73
1080	102.2	3.175	.5017	446.68	1560	92.8	2.883	.4598	603.62
1090	104.9	3.259	.5131	449.90	1570	92.0	2.858	.4561	606.49
1100	106.9	3.321	.5213	453.19	1580	91.2	2.833	.4523	609.34
1110	108.4	3.367	.5272	456.54	1590	90.4	2.808	.4484	612.16
1120	109.2	3.392	.5305	459.92	1600	89.7	2.787	.4451	614.95
1130	109.6	3.405	.5321	463.32	1610	89.0	2.765	.4417	617.73
1140	109.6	3.405	.5321	466.73	1620	88.3	2.743	.4382	620.48
1150	109.6	3.405	.5321	470.13	1630	87.6	2.721	.4347	623.21
1160	109.6	3.405	.5321	473.54	1640	86.9	2.700	.4314	625.92
1170	109.6	3.405	.5321	476.94	1650	86.2	2.678	.4278	628.61
1180	109.6	3.405	.5321	480.35	1660	85.5	2.656	.4242	631.27
1190	109.6	3.405	.5321	483.75	1670	84.8	2.634	.4206	633.92
1200	109.6	3.405	.5321	487.16	1680	84.2	2.616	.4176	636.54
1210	109.6	3.405	.5321	490.56	1690	83.6	2.597	.4145	639.15
1220	109.6	3.405	.5321	493.97	1700	83.0	2.578	.4113	641.73
1230	109.5	3.402	.5317	497.37	1710	82.4	2.560	.4082	644.30
1240	109.5	3.402	.5317	500.77	1720	81.8	2.541	.4050	646.85
1250	109.4	3.398	.5312	504.18	1730	81.2	2.522	.4018	649.39
1260	109.3	3.395	.5308	507.57	1740	80.6	2.504	.3986	651.90
1270	109.2	3.392	.5305	510.97	1750	80.0	2.485	.3953	654.39
1280	109.0	3.386	.5297	514.36	1760	79.5	2.470	.3927	656.87
1290	108.8	3.380	.5289	517.74	1770	78.9	2.451	.3893	659.33
1300	108.6	3.374	.5282	521.12	1780	78.4	2.435	.3865	661.78
1310	108.4	3.367	.5272	524.49	1790	77.8	2.417	.3833	664.20
1320	108.1	3.358	.5261	527.85	1800	77.3	2.401	.3804	666.61
1330	107.8	3.349	.5249	531.20	1810	76.8	2.386	.3777	669.01
1340	107.5	3.339	.5236	534.54	1820	76.2	2.367	.3742	671.39
1350	107.1	3.327	.5221	537.88	1830	75.7	2.352	.3714	673.75
1360	106.7	3.315	.5205	541.20	1840	75.2	2.336	.3685	676.09
1370	106.3	3.302	.5188	544.51	1850	74.7	2.321	.3657	678.42
1380	105.8	3.287	.5168	547.80	1860	74.2	2.305	.3627	680.74
1390	105.3	3.271	.5147	551.08	1870	73.6	2.286	.3591	683.03
1400	104.7	3.252	.5122	554.34	1880	73.1	2.271	.3562	685.31
1410	104.1	3.234	.5097	557.58	1890	72.6	2.255	.3532	687.58

(H) COEFFICIENTS FOR THE CUBIC LAW OF RESISTANCE.

V f-s	K_v	$\frac{K_v}{g}$	$\text{Log}\frac{K_v}{g}$	$\Sigma\frac{K_v}{g}$	V f-s	K_v	$\frac{K_v}{g}$	$\text{Log}\frac{K_v}{g}$	$\Sigma\frac{K_v}{g}$
1900	72.1	2.240	.3503	689.83	2350	62.6	1.945	.2889	784.36
1910	71.6	2.224	.3471	692.06	2360	62.0	1.926	.2847	786.29
1920	71.2	2.212	.3448	694.28	2370	61.4	1.907	.2804	788.21
1930	70.8	2.199	.3422	696.48	2380	60.8	1.889	.2762	790.11
1940	70.4	2.187	.3399	698.68	2390	60.2	1.870	.2718	791.98
1950	70.0	2.175	.3375	700.86	2400	59.6	1.851	.2674	793.85
1960	69.7	2.165	.3355	703.03	2410	59.0	1.833	.2632	795.69
1970	69.4	2.156	.3337	705.18	2420	58.4	1.814	.2586	797.51
1980	69.2	2.150	.3324	707.34	2430	57.8	1.796	.2543	799.32
1990	69.0	2.143	.3310	709.48	2440	57.2	1.777	.2497	801.10
2000	68.8	2.137	.3298	711.62	2450	56.7	1.761	.2458	802.87
2010	68.6	2.131	.3286	713.76	2460	56.2	1.746	.2420	804.63
2020	68.4	2.125	.3274	715.89	2470	55.7	1.730	.2381	806.37
2030	68.3	2.122	.3268	718.01	2480	55.2	1.715	.2343	808.09
2040	68.2	2.119	.3261	720.13	2490	54.8	1.702	.2310	809.80
2050	68.1	2.116	.3255	722.25	2500	54.4	1.690	.2279	811.50
2060	68.0	2.112	.3247	724.37	2510	54.0	1.678	.2248	813.18
2070	67.9	2.109	.3241	726.48	2520	53.7	1.668	.2222	814.85
2080	67.9	2.109	.3241	728.59	2530	53.4	1.659	.2199	816.51
2090	67.8	2.106	.3235	730.70	2540	53.1	1.650	.2175	818.17
2100	67.8	2.106	.3235	732.80	2550	52.9	1.643	.2156	819.81
2110	67.7	2.103	.3228	734.90	2560	52.7	1.637	.2141	821.45
2120	67.6	2.100	.3222	737.01	2570	52.6	1.634	.2133	823.09
2130	67.6	2.100	.3222	739.11	2580	52.5	1.631	.2125	824.72
2140	67.5	2.097	.3216	741.20	2590	52.5	1.631	.2125	826.36
2150	67.4	2.094	.3210	743.30	2600	52.4	1.628	.2117	827.99
2160	67.3	2.091	.3204	745.39	2610	52.4	1.628	.2117	829.61
2170	67.2	2.088	.3197	747.48	2620	52.4	1.628	.2117	831.24
2180	67.2	2.088	.3197	749.57	2630	52.3	1.625	.2109	832.87
2190	67.1	2.084	.3189	751.65	2640	52.3	1.625	.2109	834.50
2200	67.0	2.081	.3183	753.73	2650	52.3	1.625	.2109	836.12
2210	66.9	2.078	.3177	755.81	2660	52.2	1.622	.2101	837.74
2220	66.8	2.075	.3170	757.88	2670	52.2	1.622	.2101	839.36
2230	66.8	2.075	.3170	759.96	2680	52.2	1.622	.2101	840.99
2240	66.7	2.072	.3164	762.03	2690	52.1	1.618	.2090	842.60
2250	66.6	2.069	.3158	764.10	2700	52.1	1.618	.2090	844.22
2260	66.5	2.066	.3151	766.17	2710	52.1	1.618	.2090	845.84
2270	66.4	2.063	.3145	768.23	2720	52.0	1.615	.2082	847.46
2280	66.2	2.056	.3130	770.29	2730	52.0	1.615	.2082	849.07
2290	65.9	2.047	.3111	772.35	2740	52.0	1.615	.2082	850.69
2300	65.5	2.035	.3086	774.40	2750	52.0	1.615	.2082	852.30
2310	65.0	2.019	.3051	776.43	2760	52.0	1.615	.2082	853.92
2320	64.4	2.001	.3013	778.44	2770	52.0	1.615	.2082	855.53
2330	63.8	1.982	.2971	780.43	2780	52.0	1.615	.2082	857.15
2340	63.2	1.963	.2929	782.40	2790	52.0	1.615	.2082	858.76

(J) TABLE OF VALUES OF R_v.
PROJECTILES WITH OGIVAL-HEADS.

V f-s	0	1	2	3	4	5	6	7	8	9	Diff. +
10	25.8	27.4	29.0	30.6	32.1	33.5	35.0	36.3	37.7	39.0	1.5
11	40.3	41.5	42.7	43.9	45.0	46.1	47.2	48.3	49.3	50.3	1.1
12	51.27	52.23	53.16	54.07	54.96	55.83	56.67	57.50	58.30	59.09	87
13	59.86	60.61	61.34	62.06	62.76	63.45	64.12	64.78	65.42	66.05	69
14	66.67	67.27	67.86	68.44	69.01	69.56	70.10	70.63	71.16	71.67	55
15	72.17	72.66	73.14	73.61	74.07	74.52	74.97	75.40	75.83	76.25	45
16	76.66	77.07	77.46	77.85	78.23	78.61	78.98	79.34	79.69	80.04	38
17	80.39	80.72	81.05	81.38	81.70	82.02	82.32	82.63	82.93	83.22	32
18	83.51	83.79	84.07	84.35	84.62	84.88	85.15	85.40	85.66	85.90	26
19	86.15	86.39	86.62	86.86	87.09	87.32	87.54	87.76	87.98	88.19	23
20	88.40	88.61	88.81	89.01	89.21	89.41	89.60	89.79	89.97	90.16	20
21	90.34	90.52	90.70	90.87	91.04	91.21	91.38	91.54	91.70	91.86	17
22	92.02	92.18	92.33	92.48	92.63	92.78	92.93	93.07	93.21	93.35	15
23	93.49	93.63	93.76	93.89	94.02	94.15	94.28	94.41	94.53	94.66	13
24	94.78	94.90	95.02	95.14	95.25	95.37	95.48	95.59	95.70	95.81	11
25	95.917	6.023	6.128	6.232	6.334	6.436	6.536	6.635	6.732	6.829	101
26	96.924	7.019	7.112	7.205	7.296	7.386	7.475	7.564	7.651	7.737	90
27	97.823	7.907	7.991	8.073	8.155	8.236	8.315	8.394	8.473	8.550	81
28	98.627	8.702	8.777	8.852	8.925	8.998	9.069	9.141	9.211	9.281	73
29	99.349	9.418	9.485	9.552	9.618	9.683	9.748	9.812	9.875	9.938	65
30	0.000	0.062	0.122	0.183	0.242	0.301	0.360	0.417	0.475	0.532	59
31	0.588	0.643	0.699	0.753	0.807	0.861	0.914	0.967	1.019	1.070	54
32	1.122	1.172	1.222	1.272	1.321	1.370	1.418	1.466	1.513	1.560	49
33	1.606	1.652	1.698	1.743	1.788	1.833	1.877	1.920	1.964	2.007	44
34	2.049	2.091	2.133	2.174	2.215	2.256	2.296	2.336	2.376	2.415	41
35	2.454	2.493	2.531	2.569	2.606	2.643	2.680	2.717	2.753	2.789	37
36	2.825	2.860	2.895	2.930	2.965	2.999	3.032	3.066	3.099	3.132	34
37	3.165	3.197	3.229	3.261	3.293	3.324	3.355	3.386	3.417	3.447	31
38	3.477	3.507	3.536	3.566	3.595	3.624	3.653	3.681	3.709	3.737	29
39	3.765	3.792	3.820	3.847	3.874	3.900	3.927	3.953	3.979	4.005	27
40	4.031	4.056	4.081	4.106	4.131	4.156	4.180	4.204	4.228	4.252	25
41	4.275	4.299	4.322	4.345	4.368	4.390	4.413	4.435	4.458	4.480	23
42	4.502	4.523	4.545	4.566	4.588	4.609	4.630	4.651	4.671	4.692	21
43	4.712	4.732	4.752	4.771	4.791	4.811	4.830	4.850	4.869	4.888	20
44	4.906	4.925	4.943	4.961	4.980	4.998	5.016	5.034	5.051	5.069	18
45	5.087	5.104	5.122	5.139	5.156	5.173	5.189	5.206	5.223	5.239	17
46	5.256	5.272	5.288	5.304	5.320	5.336	5.352	5.368	5.383	5.399	16
47	5.414	5.429	5.444	5.459	5.474	5.489	5.504	5.519	5.533	5.548	15
48	5.562	5.576	5.590	5.605	5.619	5.633	5.646	5.660	5.674	5.687	14
49	5.701	5.714	5.728	5.741	5.754	5.767	5.780	5.793	5.806	5.819	13
50	5.831	5.844	5.856	5.869	5.881	5.894	5.906	5.918	5.930	5.942	12
51	5.954	5.966	5.978	5.990	6.001	6.013	6.024	6.036	6.047	6.059	11
52	6.070	6.081	6.092	6.103	6.114	6.125	6.136	6.147	6.158	6.168	11
53	6.179	6.190	6.200	6.211	6.221	6.232	6.242	6.252	6.262	6.272	10
54	*6.283*	*6.293*	6.303	6.313	6.322	6.332	6.342	6.352	6.361	6.371	10

(J) TABLE OF VALUES OF R_v.

V f-s	0	1	2	3	4	5	6	7	8	9	Diff. +
55	6.3806	.3901	.3995	.4089	.4183	.4276	.4368	.4460	.4551	.4642	94
56	.4733	.4823	.4912	.5001	.5090	.5178	.5266	.5353	.5439	.5526	88
57	.5612	.5697	.5782	.5866	.5950	.6034	.6117	.6200	.6282	.6364	84
58	6.6446	.6527	.6608	.6689	.6769	.6849	.6928	.7007	.7086	.7164	80
59	.7242	.7319	.7396	.7473	.7549	.7625	.7700	.7775	.7850	.7925	76
60	.7999	.8072	.8146	.8219	.8292	.8364	.8436	.8508	.8579	.8650	72
61	6.8721	.8792	.8862	.8932	.9001	.9070	.9139	.9208	.9276	.9344	69
62	.9411	.9478	.9545	.9612	.9678	.9744	.9810	.9875	.9940	*.0005	66
63	7.0069	.0133	.0197	.0260	.0324	.0387	.0450	.0512	.0574	.0636	63
64	7.0698	.0759	.0820	.0881	.0942	.1002	.1062	.1122	.1181	.1240	60
65	.1299	.1357	.1416	.1474	.1531	.1589	.1646	.1704	.1760	.1817	58
66	.1874	.1930	.1986	.2041	.2097	.2152	.2207	.2261	.2316	.2370	55
67	7.2424	.2478	.2531	.2584	.2637	.2690	.2742	.2795	.2847	.2898	53
68	.2950	.3001	.3052	.3103	.3154	.3205	.3255	.3305	.3355	.3404	51
69	.3454	.3503	.3552	.3601	.3650	.3698	.3747	.3795	.3843	.3891	49
70	7.3939	.3986	.4033	.4080	.4127	.4173	.4219	.4265	.4311	.4357	46
71	.4402	.4448	.4493	.4538	.4582	.4627	.4671	.4715	.4759	.4803	45
72	.4846	.4890	.4933	.4976	.5019	.5061	.5104	.5146	.5188	.5230	43
73	7.5272	.5313	.5354	.5396	.5437	.5477	.5518	.5559	.5599	.5639	41
74	.5679	.5719	.5759	.5799	.5838	.5877	.5916	.5955	.5994	.6033	39
75	.6071	.6109	.6147	.6185	.6223	.6261	.6298	.6335	.6373	.6410	38
76	7.6447	.6483	.6520	.6556	.6592	.6628	.6664	.6700	.6736	.6771	36
77	.6806	.6841	.6876	.6911	.6946	.6980	.7015	.7049	.7083	.7117	34
78	.7150	.7184	.7217	.7251	.7284	.7317	.7350	.7383	.7415	.7448	33
79	7.7480	.7512	.7544	.7576	.7608	.7640	.7671	.7703	.7734	.7765	32
80	.7796	.7827	.7858	.7889	.7919	.7950	.7980	.8010	.8040	.8070	30
81	.8100	.8129	.8159	.8188	.8217	.8246	.8275	.8304	.8333	.8361	29
82	7.8390	.8418	.8446	.8474	.8502	.8530	.8558	.8585	.8613	.8640	28
83	.8667	.8694	.8721	.8748	.8774	.8801	.8827	.8853	.8880	.8906	27
84	.8931	.8957	.8983	.9008	.9034	.9059	.9084	.9109	.9134	.9159	25
85	7.9184	.9208	.9233	.9257	.9281	.9305	.9329	.9353	.9377	.9401	24
86	.9424	.9448	.9471	.9495	.9518	.9541	.9564	.9587	.9609	.9632	23
87	.9655	.9677	.9699	.9722	.9744	.9766	.9788	.9810	.9831	.9853	22
88	7.9875	.9896	.9917	.9939	.9960	.9981	*.0002	*.0023	*.0043	*.0064	21
89	8.0085	.0105	.0125	.0146	.0166	.0186	.0206	.0226	.0246	.0265	20
90	.0285	.0305	.0324	.0344	.0363	.0382	.0401	.0420	.0439	.0458	19
91	8.0477	.0496	.0514	.0533	.0552	.0570	.0588	.0607	.0625	.0643	18
92	.0661	.0679	.0697	.0714	.0732	.0750	.0767	.0785	.0802	.0820	18
93	.0837	.0854	.0871	.0888	.0905	.0922	.0939	.0955	.0972	.0989	17
94	8.1005	.1022	.1038	.1054	.1071	.1087	.1103	.1119	.1135	.1151	16
95	.1167	.1182	.1198	.1214	.1229	.1245	.1260	.1276	.1291	.1306	16
96	.1321	.1336	.1351	.1366	.1381	.1396	.1411	.1426	.1440	.1455	15
97	8.1470	.1484	.1499	.1513	.1527	.1542	.1556	.1570	.1584	.1598	14
98	.1612	.1626	.1640	.1654	.1667	.1681	.1695	.1708	.1722	.1735	14
99	.1749	.1762	.1776	.1789	.1802	.1815	.1828	.1841	.1854	.1867	13
100	8.1880	.1893	.1906	.1918	.1931	.1944	.1956	.1969	.1982	.1994	13
101	.2006	.2019	.2031	.2043	.2055	.2068	.2080	.2092	.2104	.2115	12
102	.2127	.2139	.2151	.2163	.2174	.2186	.2197	.2209	.2220	.2231	12

(J) TABLE OF VALUES OF R_v.

V f-s	0	1	2	3	4	5	6	7	8	9	Diff. +
103	8.2 2427	2238	2649	2759	2867	2975	3082	3188	3293	3397	108
104	3500	3602	3703	3803	3902	4000	4096	4192	4286	4379	98
105	4471	4562	4652	4740	4828	4915	5001	5086	5170	5253	87
106	8.2 5336	5417	5498	5578	5658	5736	5814	5891	5968	6043	79
107	6118	6193	6267	6340	6413	6485	6557	6628	6699	6769	72
108	6839	6908	6977	7045	7113	7181	7248	7315	7381	7447	68
109	8.2 7512	7577	7642	7706	7770	7834	7897	7960	8022	8085	64
110	8146	8208	8269	8330	8390	8450	8510	8570	8630	8689	60
111	8747	8806	8864	8922	8980	9038	9095	9152	9209	9266	58
112	8.2 9322	9378	9434	9489	9545	9600	9655	9710	9764	9819	55
113	9873	9927	9981	*0034	*0088	*0141	*0194	*0246	*0299	*0351	53
114	8.3 0403	0455	0507	0559	0610	0662	0713	0764	0814	0865	51
115	8.3 0915	0966	1016	1065	1115	1165	1214	1263	1313	1362	50
116	1410	1459	1508	1556	1604	1652	1700	1748	1795	1843	48
117	1890	1937	1984	2030	2077	2123	2169	2215	2261	2307	46
118	8.3 2352	2397	2443	2488	2533	2577	2622	2666	2711	2755	45
119	2799	2843	2887	2930	2974	3017	3061	3104	3146	3189	43
120	3232	3274	3316	3359	3401	3442	3484	3526	3567	3608	42
121	8.3 3649	3690	3731	3772	3812	3852	3893	3933	3973	4012	40
122	4052	4092	4131	4171	4210	4249	4288	4327	4366	4405	39
123	4443	4482	4520	4559	4597	4635	4673	4710	4748	4786	38
124	8.3 4823	4860	4898	4935	4972	5008	5045	5082	5118	5155	37
125	5191	5227	5263	5299	5335	5371	5406	5442	5477	5512	36
126	5548	5583	5618	5653	5687	5722	5756	5791	5825	5859	35
127	8.3 5894	5928	5962	5996	6029	6063	6096	6129	6163	6196	34
128	6229	6262	6294	6327	6360	6392	6425	6457	6490	6522	33
129	6554	6586	6618	6650	6681	6713	6745	6776	6808	6839	32
130	8.3 6870	6901	6932	6963	6994	7025	7055	7086	7116	7147	31
131	7177	7207	7238	7268	7298	7328	7357	7387	7417	7446	30
132	7476	7505	7535	7564	7594	7623	7652	7681	7710	7739	29
133	8.3 7768	7797	7825	7854	7882	7911	7939	7967	7996	8024	28
134	8052	8080	8108	8135	8163	8191	8218	8246	8273	8300	28
135	8327	8355	8382	8409	8435	8462	8489	8516	8542	8569	27
136	8.3 8595	8621	8648	8674	8700	8726	8752	8778	8804	8829	26
137	8855	8881	8907	8932	8958	8983	9009	9034	9060	9085	26
138	9110	9136	9161	9186	9211	9236	9260	9285	9310	9334	25
139	8.3 9359	9383	9407	9432	9456	9480	9504	9529	9553	9577	24
140	9601	9625	9649	9673	9696	9720	9744	9768	9791	9815	24
141	9838	9862	9885	9909	9932	9955	9978	*0002	*0025	*0048	23
142	8.4 0071	0094	0117	0140	0163	0185	0208	0231	0254	0276	23
143	0299	0321	0344	0366	0389	0411	0433	0455	0478	0500	22
144	0522	0544	0566	0588	0610	0631	0653	0675	0697	0718	22
145	8.4 0740	0761	0783	0804	0826	0847	0868	0889	0911	0932	21
146	0953	0974	0995	1016	1037	1058	1079	1099	1120	1141	21
147	1161	1182	1203	1223	1243	1264	1284	1304	1325	1345	20
148	8.4 1365	1385	1406	1426	1446	1466	1486	1506	1526	1546	20
149	1566	1586	1606	1626	1645	1665	1685	1705	1724	1744	20
150	*1764*	*1783*	1803	1823	1842	1862	1881	1900	1920	1939	20

(J) TABLE OF VALUES OF R_v.

V f-s	0	1	2	3	4	5	6	7	8	9	Diff. +
151	8.4 1958	1978	1997	2016	2035	2054	2073	2092	2111	2130	19
152	2149	2167	2186	2205	2224	2242	2261	2279	2298	2317	19
153	2335	2354	2372	2390	2409	2427	2445	2464	2482	2500	18
154	8.4 2518	2536	2554	2573	2591	2609	2626	2644	2662	2680	18
155	2698	2716	2733	2751	2769	2787	2804	2822	2840	2857	18
156	2875	2893	2910	2928	2945	2963	2980	2998	3015	3033	18
157	8.4 3050	3067	3085	3102	3119	3137	3154	3171	3188	3205	17
158	3222	3239	3256	3273	3290	3307	3324	3341	3358	3374	17
159	3391	3408	3424	3441	3458	3474	3491	3507	3524	3540	17
160	8.4 3556	3573	3589	3605	3622	3638	3654	3671	3687	3703	16
161	3719	3735	3751	3767	3783	3799	3815	3831	3847	3863	16
162	3879	3895	3911	3927	3942	3958	3974	3990	4005	4021	16
163	8.4 4037	4052	4068	4083	4099	4114	4130	4145	4161	4176	15
164	4191	4207	4222	4237	4252	4268	4283	4298	4313	4328	15
165	4343	4359	4374	4389	4404	4419	4434	4449	4464	4478	15
166	8.4 4493	4508	4523	4538	4553	4567	4582	4597	4612	4626	15
167	4641	4656	4670	4685	4699	4714	4728	4743	4758	4772	15
168	4786	4801	4815	4830	4844	4858	4872	4887	4901	4915	14
169	8.4 4929	4943	4958	4972	4986	5000	5014	5028	5042	5056	14
170	5070	5084	5098	5112	5125	5139	5153	5167	5181	5194	14
171	5208	5222	5235	5249	5263	5276	5290	5304	5317	5331	14
172	8.4 5344	5358	5371	5385	5398	5412	5425	5438	5452	5465	13
173	5478	5492	5505	5518	5531	5544	5558	5571	5584	5597	13
174	5610	5623	5636	5649	5662	5675	5688	5701	5714	5727	13
175	8.4 5740	5753	5766	5778	5791	5804	5817	5829	5842	5855	13
176	5868	5880	5893	5905	5918	5931	5943	5956	5968	5981	13
177	5993	6006	6018	6031	6043	6055	6068	6080	6092	6105	12
178	8.4 6117	6129	6142	6154	6166	6178	6190	6203	6215	6227	12
179	6239	6251	6263	6275	6287	6299	6311	6323	6335	6347	12
180	6359	6371	6383	6395	6406	6418	6430	6442	6453	6465	12
181	84. 6477	6489	6500	6512	6524	6535	6547	6558	6570	6582	12
182	6593	6605	6616	6628	6639	6651	6662	6673	6685	6696	11
183	6708	6719	6730	6742	6753	6764	6775	6787	6798	6809	11
184	8.4 6820	6832	6843	6854	6865	6876	6887	6898	6909	6920	11
185	6931	6942	6953	6964	6975	6986	6997	7008	7019	7030	11
186	7041	7052	7063	7073	7084	7095	7106	7117	7127	7138	11
187	8.4 7149	7160	7170	7181	7192	7202	7213	7224	7234	7245	11
188	7255	7266	7276	7287	7297	7308	7318	7329	7339	7350	10
189	7360	7371	7381	7391	7402	7412	7422	7433	7443	7453	10
190	8.4 7464	7474	7484	7494	7505	7515	7525	7535	7545	7556	10
191	7566	7576	7586	7596	7606	7616	7626	7636	7646	7656	10
192	7666	7676	7686	7696	7706	7716	7726	7736	7746	7755	10
193	8.4 7765	7775	7785	7795	7804	7814	7824	7834	7843	7853	10
194	7863	7872	7882	7892	7901	7911	7920	7930	7940	7949	10
195	7959	7968	7978	7987	7997	8006	8016	8025	8034	8044	9
196	8.4 8053	8063	8072	8081	8091	8100	8109	8119	8128	8137	9
197	8146	8156	8165	8174	8183	8192	8202	8211	8220	8229	9
198	8238	8247	8256	8265	8274	8283	8292	8301	8310	8319	9

(J) TABLE OF VALUES OF R_v.

V f-s	0	1	2	3	4	5	6	7	8	9	Diff. +
199	8.48 3280	3369	3458	3547	3635	3724	3812	3900	3988	4076	89
200	4164	4251	4338	4426	4513	4600	4686	4773	4859	4946	87
201	5032	5118	5204	5289	5375	5460	4546	5631	5716	5801	86
202	8.48 5886	5971	6055	6139	6224	6308	6391	6475	6559	6642	84
203	6725	6808	6891	6974	7056	7139	7221	7304	7386	7468	83
204	7549	7631	7713	7794	7876	7957	8038	8119	8200	8280	81
205	8.48 8361	8441	8521	8601	8681	8761	8840	8920	8999	9078	80
206	9157	9236	9315	9394	9472	9551	9629	9707	9785	9863	78
207	9941	*0018	*0096	*0173	*0250	*0327	*0404	*0481	*0557	*0633	77
208	8.49 0710	0786	0861	0937	1013	1088	1163	1239	1314	1389	75
209	1463	1538	1613	1687	1761	1835	1909	1983	2057	2130	74
210	2203	2276	2349	2422	2495	2568	2640	2713	2785	2857	73
211	8.49 2930	3002	3073	3145	3217	3288	3359	3431	3502	3572	71
212	3643	3714	3784	3855	3925	3995	4065	4135	4205	4274	70
213	4344	4413	4482	4551	4620	4689	4758	4827	4895	4963	69
214	8.49 5031	5100	5167	5235	5303	5370	5438	5505	5572	5639	68
215	5706	5773	5840	5907	5973	6040	6106	6173	6239	6305	67
216	6371	6437	6503	6568	6634	6699	6764	6829	6894	6959	65
217	8.49 7024	7089	7153	7218	7282	7346	7411	7475	7539	7603	64
218	7666	7730	7794	7857	7921	7984	8047	8110	8173	8236	63
219	8299	8361	8424	8486	8548	8611	8673	8734	8796	8858	62
220	8.49 8920	8981	9042	9104	9165	9226	9287	9348	9409	9470	61
221	9531	9591	9651	9712	9772	9832	9892	9952	*0011	*0071	60
222	8.50 0130	0189	0249	0308	0367	0426	0484	0543	0602	0660	59
223	8.50 0719	0777	0835	0893	0951	1009	1067	1125	1183	1240	58
224	1298	1355	1413	1470	1527	1584	1641	1698	1755	1811	57
225	1868	1925	1981	2037	2093	2150	2206	2262	2318	2373	56
226	8.50 2429	2485	2540	2596	2651	2706	2761	2817	2872	2926	55
227	2981	3036	3091	3145	3200	3254	3308	3363	3417	3471	54
228	3525	3579	3633	3687	3741	3794	3848	3901	3955	4008	54
229	8.50 4062	4115	4168	4221	4274	4327	4380	4433	4486	4538	53
230	4591	4644	4696	4749	4801	4854	4906	4958	5011	5063	52
231	5115	5167	5219	5271	5323	5375	5427	5479	5531	5582	52
232	8.50 5634	5686	5737	5789	5841	5892	5944	5995	6046	6098	52
233	6149	6200	6252	6303	6354	6405	6456	6507	6558	6609	51
234	6660	6711	6762	6813	6864	6914	6965	7016	7066	7117	51
235	8.50 7167	7218	7268	7319	7369	7419	7470	7520	7570	7621	50
236	7671	7721	7771	7821	7872	7922	7972	8022	8071	8121	50
237	8171	8221	8271	8321	8370	8420	8470	8519	8569	8618	50
238	8.50 8668	8717	8767	8816	8866	8915	8964	9014	9063	9112	49
239	9161	9210	9260	9309	9358	9407	9456	9505	9553	9602	49
240	9651	9700	9749	9797	9846	9895	9944	9992	*0041	*0089	49
241	8.51 0138	0186	0235	0283	0332	0380	0428	0477	0525	0573	48
242	0621	0670	0718	0766	0814	0862	0910	0958	1006	1054	48
243	1102	1150	1198	1245	1293	1341	1389	1436	1484	1532	48
244	8.51 1579	1627	1674	1722	1769	1817	1864	1912	1959	2006	47
245	2053	2101	2148	2195	2242	2289	2336	2383	2430	2477	47
246	2524	2571	2618	2665	2711	2758	2805	2852	2898	2945	47

(J) TABLE OF VALUES OF R_v.

V f-s	0	1	2	3	4	5	6	7	8	9	Diff. +
247	8.51 2992	3038	3085	3131	3178	3224	3271	3317	3363	3410	47
248	3456	3502	3548	3594	3640	3687	3733	3779	3825	3870	46
249	3916	3962	4008	4054	4100	4145	4191	4237	4282	4328	46
250	8.51 4374	4419	4465	4510	4555	4601	4646	4691	4736	4782	45
251	4827	4872	4917	4962	5007	5052	5097	5142	5186	5231	45
252	5276	5320	5365	5409	5454	5498	5543	5587	5631	5676	44
253	8.51 5720	5764	5808	5852	5896	5940	5984	6028	6072	6115	44
254	6159	6203	6246	6290	6333	6377	6420	6464	6507	6550	44
255	6594	6637	6680	6723	6766	6809	6852	6894	6937	6980	43
256	8.51 7023	7065	7108	7150	7193	7235	7278	7320	7362	7404	42
257	7447	7489	7531	7573	7615	7656	7698	7740	7782	7823	42
258	7865	7907	7948	7989	8031	8072	8113	8154	8196	8237	41
259	8.51 8278	8319	8359	8400	8441	8482	8522	8563	8604	8644	41
260	8685	8725	8765	8806	8846	8886	8926	8966	9006	9046	40
261	9086	9126	9166	9206	9245	9285	9324	9364	9403	9443	40
262	8.51 9482	9521	9560	9599	9638	9677	9716	9755	9794	9833	39
263	9872	9910	9949	9987	*0026	*0064	*0102	*0141	*0179	*0217	38
264	8.52 0255	0293	0331	0369	0407	0445	0483	0520	0558	0595	38
265	8.52 0633	0670	0708	0745	0782	0819	0857	0894	0931	0968	37
266	1005	1042	1079	1115	1152	1189	1226	1262	1299	1335	37
267	1371	1408	1444	1480	1516	1553	1589	1625	1661	1697	36
268	8.52 1732	1768	1804	1840	1875	1911	1947	1982	2018	2053	36
269	2088	2124	2159	2194	2229	2265	2300	2335	2369	2404	35
270	2439	2474	2508	2543	2578	2612	4647	2681	2715	2750	35
271	8.52 2784	2818	2852	2887	2921	2955	2989	3023	3057	3091	34
272	3124	3158	3192	3226	3259	3293	3327	3360	3394	3427	34
273	3461	3494	3538	3561	3594	3627	3661	3694	3727	3760	33
274	8.52 3793	3826	3859	3891	3924	3957	3990	4022	4055	4087	33
275	4120	4152	4185	4217	4249	4281	4314	4346	4378	4410	32
276	4442	4474	4506	4538	4570	4602	4634	4665	4697	4729	32
277	8.52 4760	4792	4823	4855	4886	4917	4949	4980	5011	5042	31
278	5073	5105	5136	5167	5198	5229	5259	5290	5321	5352	31
279	5383	5413	5444	5475	5505	5536	5566	5597	5627	5657	31

(K) TABLE OF VALUES OF $[1000 \div v]^3$

27	50.81	50.24	49.69	49.15	48.61	48.08	47.56	47.05	46.54	46.05	53
28	45.55	45.07	44.59	44.12	43.66	43.20	42.75	42.30	41.86	41.43	46
29	41.00	40.58	40.17	39.76	39.35	38.95	38.56	38.17	37.79	37.41	40
30	37.04	36.67	36.31	35.95	35.59	35.25	34.90	34.56	34.23	33.90	35
31	33.57	33.24	32.93	32.61	32.30	31.99	31.69	31.39	31.10	30.81	31
32	30.52	30.23	29.95	29.68	29.40	29.13	28.86	28.60	28.34	28.08	27
33	27.83	27.58	27.33	27.08	26.84	26.60	26.36	26.13	25.90	25.67	24
34	25.44	25.22	25.00	24.78	24.57	24.35	24.14	23.93	23.73	23.53	21
35	23.32	23.13	22.93	22.73	22.54	22.35	22.16	21.98	21.80	21.61	19

K. TABLE OF VALUES OF $(1000 \div v)^3$

v		0	1	2	3	4	5	6	7	8	9	Diff +
36		21.43	21.26	21.08	20.91	20.73	20.56	20.40	20.23	20.07	19.90	17
37		19.74	19.58	19.43	19.27	19.12	18.96	18.81	18.66	18.52	18.37	15
38		18.22	18.08	17.94	17.80	17.66	17.52	17.39	17.25	17.12	16.99	14
39		16.86	16.73	16.60	16.48	16.35	16.23	16.10	15.98	15.86	15.74	12
40		15.63	15.51	15.39	15.28	15.17	15.05	14.94	14.83	14.72	14.62	11
41		14.51	14.40	14.30	14.20	14.09	13.99	13.89	13.79	13.69	13.59	10
42	1	3.497	3.401	3.306	3.212	3.119	3.027	2.935	2.845	2.755	2.666	92
43		2.578	2.491	2.404	2.318	2.233	2.149	2.065	1.983	1.901	1.820	84
44		1.739	1.660	1.581	1.502	1.425	1.348	1.272	1.196	1.122	1.048	77
45	1	0.974	0.901	0.829	0.757	0.686	0.616	0.547	0.478	0.409	0.341	70
46		0.274	0.207	0.141	0.075	0.010	*9.946	*9.882	*9.819	*9.756	*9.694	64
47		9.632	9.571	9.510	9.450	9.390	9.331	9.272	9.214	9.156	9.099	59
48		9.042	8.986	8.930	8.875	8.820	8.766	8.711	8.658	8.605	8.552	54
49		8.500	8.448	8.397	8.346	8.295	8.245	8.195	8.146	8.097	8.048	50

FOR VELOCITIES 500 TO 1999 f-s SEE TABLE (F).

v		0	1	2	3	4	5	6	7	8	9	Diff +
200	.1	2500	2481	2463	2444	2426	2407	2388	2370	2351	2333	19
201		2314	2296	2277	2259	2240	2222	2204	2186	2168	2150	18
202		2132	2114	2096	2078	2060	2042	2025	2007	1989	1972	18
203	.1	1954	1936	1919	1901	1884	1866	1849	1831	1814	1796	17
204		1779	1762	1744	1727	1710	1693	1676	1659	1642	1625	17
205		1608	1591	1574	1557	1540	1523	1506	1489	1473	1456	17
206	.1	1439	1423	1406	1389	1373	1356	1340	1323	1307	1290	16
207		1274	1258	1241	1225	1209	1193	1177	1161	1145	1129	16
208		1113	1097	1081	1065	1049	1033	1017	1002	0986	0970	16
209	.1	0954	0939	0923	0907	0892	0876	0860	0845	0829	0814	16
210		0798	0783	0767	0752	0736	0721	0706	0690	0675	0660	15
211		0645	0630	0615	0600	0585	0570	0555	0540	0525	0510	15
212	.1	0495	0480	0465	0451	0436	0421	0407	0392	0377	0363	15
213		0348	0333	0319	0304	0290	0276	0261	0247	0233	0218	14
214		0204	0190	0176	0161	0147	0133	0119	0104	0090	0076	14
215	.1	0062	0048	0034	0020	0006	*9992	*9978	*9964	*9951	*9937	14
216	.0	9923	9909	9895	9882	9868	9854	9841	9827	9813	9800	14
217		9786	9772	9759	9746	9732	9719	9706	9692	9679	9665	13
218	.0	9652	9639	9625	9612	9599	9586	9573	9560	9547	9534	13
219		9521	9508	9495	9482	9469	9456	9443	9430	9417	9404	13
220		9391	9378	9365	9352	9340	9327	9315	9302	9290	9277	13
221	.0	9265	9252	9240	9227	9215	9202	9190	9177	9165	9152	12
222		9140	9128	9116	9103	9091	9079	9067	9055	9042	9030	12
223		9018	9006	8994	8982	8970	8958	8946	8934	8922	8910	12
224	.0	8898	8886	8874	8862	8850	8838	8826	8814	8803	8791	12
225		8779	8768	8756	8744	8733	8721	8709	8698	8686	8675	12
226		8663	8652	8640	8629	8617	8606	8595	8583	8572	8560	11
227	.0	8549	8538	8526	8515	8504	8493	8482	8470	8459	8448	11
228		8437	8426	8415	8404	8393	8382	8371	8360	8349	8338	11
229		8327	8316	8305	8295	8284	8273	8262	8251	8241	8230	11
230	.0	8219	8208	8198	8187	8176	8166	8155	8144	8134	8123	11
231		8113	8102	8092	8082	8071	8062	8050	8039	8029	8019	10
232		8008	7998	7988	7977	7967	7957	7947	7936	7926	7916	10

(K) TABLE OF VALUES OF $[1000 \div v]^3$

V f-s	0		1	2	3	4	5	6	7	8	9	Diff. +
233	.0	7906	7895	7885	7875	7865	7855	7845	7835	7825	7815	10
234		7805	7795	7785	7775	7765	7755	7745	7735	7725	7715	10
235		7705	7696	7686	7676	7666	7656	7647	7637	7627	7618	10
236	.07	6079	5982	5886	5789	5693	5597	5501	5406	5310	5215	96
237		5120	5025	4930	4835	4741	4646	4552	4458	4364	4271	95
238		4177	4084	3991	3898	3805	3712	3619	3527	3434	3342	93
239	.07	3250	3158	3066	2974	2883	2792	2701	2610	2519	2429	91
240		2338	2248	2158	2068	1978	1888	1798	1709	1619	1530	90
241		1441	1352	1263	1175	1086	0998	0910	0822	0734	0647	88
242	.07	0559	0472	0385	0298	0211	0124	0038	*9951	*9865	*9778	87
243	.06	9692	9606	9520	9434	9349	9263	9178	9093	9008	8923	86
244		8838	8754	8669	8585	8501	8417	8333	8250	8166	8083	84
245	.06	7999	7916	7833	7750	7667	7584	7502	7419	7337	7255	83
246		7173	7091	7010	6928	6847	6765	6684	6603	6522	6442	82
247		6361	6280	6200	6119	6039	5959	5879	5800	5720	5641	80
248	.06	5561	5482	5403	5324	5246	5167	5088	5010	4931	4853	79
249		4775	4697	4619	4541	4464	4386	4309	4231	4154	4077	78
250		4000	3923	3847	3770	3694	3618	3542	3466	3390	3315	76
251	.06	3239	3164	3088	3013	2937	2862	2787	2712	2637	2563	75
252		2488	2414	2340	2266	2192	2118	2045	1971	1898	1824	74
253		1751	1678	1605	1532	1459	1386	1314	1241	1169	1096	73
254	.06	1024	0952	0880	0809	0737	0666	0594	0523	0452	0381	71
255		0310	0239	0168	0097	0027	*9956	*9886	*9815	*9745	*9675	71
256	.05	9605	9535	9465	9395	9326	9256	9187	9117	9048	8979	70
257	.05	8910	8841	8773	8704	8636	8568	8500	8432	8364	8296	68
258		8228	8160	8093	8025	7958	7891	7824	7757	7690	7624	67
259		7557	7490	7424	7357	7291	7225	7159	7093	7027	6962	66
260	.05	6896	6830	6765	6699	6634	6568	6503	6438	6373	6308	66
261		6243	6179	6114	6050	5985	5921	5857	5793	5729	5666	64
262		5602	5539	5475	5412	5349	5286	5223	5160	5097	5035	63
263	.05	4972	4909	4847	4784	4722	4659	4597	4534	4472	4410	63
264		4348	4287	4225	4163	4102	4040	3979	3918	3857	3796	62
265		3735	3675	3614	3553	3493	3432	3372	3312	3252	3192	61
266	.05	3132	3073	3013	2953	2894	2834	2775	2715	2656	2597	60
267		2538	2479	2420	2361	2302	2243	2185	2126	2068	2009	59
268		1951	1893	1835	1777	1719	1661	1604	1546	1489	1431	58
269	.05	1374	1317	1259	1202	1145	1088	1032	0975	0918	0862	57
270		0805	0749	0692	0636	0580	0524	0468	0412	0356	0300	56
271		0244	0189	0133	0077	0022	*9966	*9911	*9856	*9801	*9746	56
272	.04	9691	9637	9582	9528	9473	9419	9365	9311	9257	9203	54
273		9149	9095	9041	8987	8934	8880	8826	8773	8719	8666	54
274		8613	8560	8507	8454	8401	8348	8295	8242	8189	8137	53
275	.04	8084	8032	7979	7927	7874	7822	7770	7718	7666	7614	52
276		7562	7511	7459	7408	7356	7305	7254	7203	7152	7101	51
277		7050	6999	6948	6897	6847	6796	6746	6695	6645	6594	51
278	.04	6544	6494	6444	6394	6344	6294	6244	6194	6144	6095	50
279		6045	5996	5946	5897	5848	5799	5750	5701	5652	5603	49
280		5554	5506	5457	5408	5360	5311	5262	5214	5165	5117	49

(K) TABLE OF VALUES OF $[1000 \div v]^3$

V f-s	0	1	2	3	4	5	6	7	8	9	Diff +
36	21.43	21.26	21.08	20.91	20.74	20.57	20.40	20.23	20.07	19.90	17
37	19.74	19.58	19.43	19.27	19.12	18.96	18.81	18.66	18.52	18.37	15
38	18.22	18.08	17.94	17.80	17.66	17.52	17.39	17.25	17.12	16.99	14
39	16.86	16.73	16.60	16.48	16.35	16.23	16.10	15.98	15.86	15.74	12
40	15.63	15.51	15.39	15.28	15.17	15.05	14.94	14.83	14.72	14.62	11
41	14.51	14.40	14.30	14.20	14.09	13.99	13.89	13.79	13.69	13.59	10
42	1 3.497	3.401	3.306	3.212	3.119	3.027	2.935	2.845	2.755	2.666	92
43	2.578	2.491	2.404	2.318	2.233	2.149	2.065	1.983	1.901	1.820	84
44	1.739	1.660	1.581	1.503	1.425	1.348	1.272	1.197	1.122	1.048	77
45	1 0.974	0.901	0.829	0.757	0.686	0.616	0.547	0.478	0.409	0.341	70
46	0.274	0.207	0.141	0.075	0.010	*9.946	*9.882	*9.819	*9.756	*9.694	64
47	0 9.632	9.571	9.510	9.450	9.390	9.331	9.272	9.214	9.156	9.099	59
48	9.042	8.986	8.930	8.875	8.820	8.766	8.711	8.658	8.605	8.552	54
49	8.500	8.448	8.397	8.346	8.295	8.245	8.195	8.146	8.097	8.048	50

FOR VELOCITIES 500 TO 1999 f-s SEE TABLE (F).

V f-s	0	1	2	3	4	5	6	7	8	9	Diff +
200	.1 2500	2481	2463	2444	2426	2407	2388	2370	2351	2333	19
201	2314	2296	2277	2259	2240	2222	2204	2186	2168	2150	18
202	2132	2114	2096	2078	2060	2042	2025	2007	1989	1972	18
203	.1 1954	1936	1919	1901	1884	1866	1849	1831	1814	1796	17
204	1779	1762	1744	1727	1710	1693	1676	1659	1642	1625	17
205	1608	1591	1574	1557	1540	1523	1506	1489	1473	1456	17
206	.1 1439	1423	1406	1389	1373	1356	1340	1323	1307	1290	16
207	1274	1258	1241	1225	1209	1193	1177	1161	1145	1129	16
208	1113	1097	1081	1065	1049	1033	1017	1002	0986	0970	16
209	.1 0954	0939	0923	0907	0892	0876	0860	0845	0829	0814	16
210	0798	0783	0767	0752	0736	0721	0706	0690	0675	0660	15
211	0645	0630	0615	0600	0585	0570	0555	0540	0525	0510	15
212	.1 0495	0480	0465	0451	0436	0421	0407	0392	0377	0363	15
213	0348	0333	0319	0304	0290	0276	0261	0247	0233	0218	14
214	0204	0190	0176	0161	0147	0133	0119	0104	0090	0076	14
215	.1 0062	0048	0034	0020	0006	*9992	*9978	*9964	*9951	*9937	14
216	.0 9923	9909	9895	9882	9868	9854	9841	9827	9813	9800	14
217	9786	9772	9759	9746	9732	9719	9706	9692	9679	9665	13
218	.0 9652	9639	9625	9612	9599	9586	9573	9560	9547	9534	13
219	9521	9508	9495	9482	9469	9456	9443	9430	9417	9404	13
220	9391	9378	9365	9352	9340	9327	9315	9302	9290	9277	13
221	.0 9265	9252	9240	9227	9215	9202	9190	9177	9165	9152	12
222	9140	9128	9116	9103	9091	9079	9067	9055	9042	9030	12
223	9018	9006	8994	8982	8970	8958	8946	8934	8922	8910	12
224	.0 8898	8886	8874	8862	8850	8838	8826	8814	8803	8791	12
225	8779	8768	8756	8744	8733	8721	8709	8698	8686	8675	12
226	8663	8652	8640	8629	8617	8606	8595	8583	8572	8560	11
227	.0 8549	8538	8526	8515	8504	8493	8482	8470	8459	8448	11
228	8437	8426	8415	8404	8393	8382	8371	8360	8349	8338	11
229	8327	8316	8305	8295	8284	8273	8262	8251	8241	8230	11
230	.0 8219	8208	8198	8187	8176	8166	8155	8144	8134	8123	11
231	8113	8102	8092	8082	8071	8062	8050	8039	8029	8019	10
232	*8008*	*7998*	7988	7977	7967	7957	7947	7936	7926	7916	10

(K) TABLE OF VALUES OF $[1000 \div v]^3$

V f-s	0	1	2	3	4	5	6	7	8	9	Diff. +
233	.0 7906	7895	7885	7875	7865	7855	7845	7835	7825	7815	10
234	7805	7795	7785	7775	7765	7755	7745	7735	7725	7715	10
235	7705	7696	7686	7676	7666	7656	7647	7637	7627	7618	10
236	.07 6079	5982	5886	5789	5693	5597	5501	5406	5310	5215	96
237	5120	5025	4930	4835	4741	4646	4552	4458	4364	4271	95
238	4177	4084	3991	3898	3805	3712	3619	3527	3434	3342	93
239	.07 3250	3158	3066	2974	2883	2792	2701	2610	2519	2429	91
240	2338	2248	2158	2068	1978	1888	1798	1709	1619	1530	90
241	1441	1352	1263	1175	1086	0998	0910	0822	0734	0647	88
242	.07 0559	0472	0385	0298	0211	0124	0038	*9951	*9865	*9778	87
243	.06 9692	9606	9520	9434	9349	9263	9178	9093	9008	8923	86
244	8838	8754	8669	8585	8501	8417	8333	8250	8166	8083	84
245	.06 7999	7916	7833	7750	7667	7584	7502	7419	7337	7255	83
246	7173	7091	7010	6928	6847	6765	6684	6603	6522	6442	82
247	6361	6280	6200	6119	6039	5959	5879	5800	5720	5641	80
248	.06 5561	5482	5403	5324	5246	5167	5088	5010	4931	4853	79
249	4775	4697	4619	4541	4464	4386	4309	4231	4154	4077	78
250	4000	3923	3847	3770	3694	3618	3542	3466	3390	3315	76
251	.06 3239	3164	3088	3013	2937	2862	2787	2712	2637	2563	75
252	2488	2414	2340	2266	2192	2118	2045	1971	1898	1824	74
253	1751	1678	1605	1532	1459	1386	1314	1241	1169	1096	73
254	.06 1024	0952	0880	0809	0737	0666	0594	0523	0452	0381	71
255	0310	0239	0168	0097	0027	*9956	*9886	*9815	*9745	*9675	71
256	.05 9605	9535	9465	9395	9326	9256	9187	9117	9048	8979	70
257	.05 8910	8841	8773	8704	8636	8568	8500	8432	8364	8296	68
258	8228	8160	8093	8025	7958	7891	7824	7757	7690	7624	67
259	7557	7490	7424	7357	7291	7225	7159	7093	7027	6962	66
260	.05 6896	6830	6765	6699	6634	6568	6503	6438	6373	6308	66
261	6243	6179	6114	6050	5985	5921	5857	5793	5729	5666	64
262	5602	5539	5475	5412	5349	5286	5223	5160	5097	5035	63
263	.05 4972	4909	4847	4784	4722	4659	4597	4534	4472	4410	63
264	4348	4287	4225	4163	4102	4040	3979	3918	3857	3796	62
265	3735	3675	3614	3553	3493	3432	3372	3312	3252	3192	61
266	.05 3132	3073	3013	2953	2894	2834	2775	2715	2656	2597	60
267	2538	2479	2420	2361	2302	2243	2185	2126	2068	2009	59
268	1951	1893	1835	1777	1719	1661	1604	1546	1489	1431	58
269	.05 1374	1317	1259	1202	1145	1088	1032	0975	0918	0862	57
270	0805	0749	0692	0636	0580	0524	0468	0412	0356	0300	56
271	0244	0189	0133	0077	0022	*9966	*9911	*9856	*9801	*9746	56
272	.04 9691	9637	9582	9528	9473	9419	9365	9311	9257	9203	54
273	9149	9095	9041	8987	8934	8880	8826	8773	8719	8666	54
274	8613	8560	8507	8454	8401	8348	8295	8242	8189	8137	53
275	.04 8084	8032	7979	7927	7874	7822	7770	7718	7666	7614	52
276	7562	7511	7459	7408	7356	7305	7254	7203	7152	7101	51
277	7050	6999	6948	6897	6847	6796	6746	6695	6645	6594	51
278	.04 6544	6494	6444	6394	6344	6294	6244	6194	6144	6095	50
279	6045	5996	5946	5897	5848	5799	5750	5701	5652	5603	49
280	5554	5506	5457	5408	5360	5311	5262	5214	5165	5117	49

(L) TABLE OF VALUES OF T_v.
PROJECTILES WITH OGIVAL HEADS.

V	0	1	2	3	4	5	6	7	8	9	Diff.
f·s	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	+
10	75.4	77.1	78.8	80.4	82.1	83.6	85.2	86.7	88.2	89.7	1.6
11	91.1	92.5	93.9	95.3	96.6	98.0	99.3	^{0}0.5	^{0}1.8	^{0}3.0	1.3
12	1 04.2	05.4	06.6	07.7	08.9	10.0	11.1	12.2	13.2	14.3	1.1
13	1 15.3	16.3	17.3	18.3	19.3	20.3	21.2	22.1	23.0	23.9	1.0
14	24.8	25.7	26.6	27.4	28.3	29.1	29.9	30.7	31.5	32.3	.8
15	33.1	33.8	34.6	35.3	36.1	36.8	37.5	38.2	38.9	39.6	.7
16	14 0.28	0.96	1.62	2.27	2.92	3.56	4.19	4.81	5.43	6.04	.64
17	6.64	7.24	7.82	8.40	8.98	9.55	^{0}.11	^{0}.66	^{1}.21	^{1}.75	.57
18	15 2.29	2.82	3.35	3.87	4.38	4.89	5.39	5.89	6.38	6.87	.51
19	15 7.35	7.83	8.30	8.77	9.23	9.69	^{0}.14	^{0}.59	^{1}.03	^{1}.47	.46
20	16 1.90	2.33	2.76	3.18	3.60	4.01	4.42	4.83	5.23	5.63	.41
21	6.02	6.41	6.80	7.18	7.56	7.94	8.31	8.68	9.04	9.40	.38
22	16 9.76	^{0}.12	^{0}.47	^{0}.82	^{1}.17	^{1}.51	^{1}.85	^{2}.19	^{2}.52	^{2}.85	.34
23	17 3.18	3.51	3.83	4.15	4.47	4.78	5.09	5.40	5.71	6.01	.32
24	6.31	6.61	6.91	7.20	7.49	7.78	8.07	8.35	8.64	8.92	.29
25	17 9.19	9.47	9.74	^{0}.01	^{0}.28	^{0}.55	^{0}.82	^{1}.08	^{1}.34	^{1}.60	.27
26	18 1.86	2.11	2.36	2.61	2.86	3.11	3.36	3.60	3.84	4.08	.25
27	4.32	4.55	4.79	5.02	5.25	5.48	5.71	5.94	6.16	6.38	.23
28	18 6.60	6.82	7.04	7.26	7.47	7.69	7.90	8.11	8.32	8.53	.21
29	8.73	8.94	9.14	9.35	9.55	9.75	9.94	^{0}.14	^{0}.34	^{0}.53	.20
30	19 0.72	0.91	1.10	1.29	1.48	1.66	1.85	2.03	2.22	2.40	.19
31	19 2.58	2.76	2.93	3.11	3.29	3.46	3.63	3.81	3.97	4.15	.17
32	4.32	4.48	4.65	4.82	4.98	5.15	5.31	5.47	5.63	5.79	.16
33	5.95	6.11	6.27	6.42	6.58	6.73	6.88	7.04	7.19	7.34	.15
34	19 7.49	7.64	7.79	7.93	8.08	8.22	8.37	8.51	8.65	8.79	.15
35	8.94	9.08	9.21	9.35	9.49	9.63	9.76	9.90	^{0}.03	^{0}.17	.14
36	20 0.30	0.43	0.56	0.69	0.82	0.95	1.08	1.21	1.33	1.46	.13
37	20 1.59	1.71	1.83	1.96	2.08	2.20	2.32	2.44	2.56	2.68	.12
38	2.80	2.92	3.04	3.15	3.27	3.38	3.50	3.61	3.72	3.84	.12
39	3.95	4.06	4.17	4.28	4.39	4.50	4.60	4.71	4.82	4.92	.11
40	20 5.03	5.13	5.24	5.34	5.45	5.55	5.65	5.75	5.85	5.96	.10
41	6.06	6.16	6.25	6.35	6.45	6.55	6.65	6.74	6.84	6.93	.10
42	7.03	7.12	7.22	7.31	7.40	7.49	7.59	7.68	7.77	7.86	.09
43	20 7.95	8.04	8.13	8.22	8.31	8.39	8.48	8.57	8.66	8.74	.09
44	8.83	8.91	9.00	9.08	9.17	9.25	9.33	9.42	9.50	9.58	.08
45	9.66	9.74	9.82	9.91	9.99	^{0}.07	^{0}.14	^{0}.22	^{0}.30	^{0}.38	.08
46	21 0.46	0.54	0.61	0.69	0.77	0.84	0.92	1.00	1.07	1.15	.08
47	1.22	1.29	1.37	1.44	1.52	1.59	1.66	1.73	1.81	1.88	.07
48	1.95	2.02	2.09	2.16	2.23	2.30	2.37	2.44	2.51	2.58	.07
49	21 2.65	2.71	2.78	2.85	2.92	2.98	3.05	3.12	3.18	3.25	.07
50	3.32	3.38	3.45	3.51	3.58	3.64	3.71	3.77	3.83	3.90	.06
51	3.96	4.02	4.08	4.15	4.21	4.27	4.33	4.39	4.46	4.52	.06

(M) TABLE OF VALUES OF S_v.
PROJECTILES WITH OGIVAL HEADS.

V	0	1	2	3	4	5	6	7	8	9	Diff.
f-s	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	+
10	1066	1238	1409	1578	1745	1910	2074	2236	2397	2557	166
11	2715	2871	3026	3180	3333	3484	3633	3782	3929	4075	151
12	4220	4363	4506	4647	4787	4926	5064	5200	5336	5471	139
13	5604	5737	5866	5999	6129	6257	6385	6511	6637	6762	129
14	6886	7009	7132	7253	7373	7493	7612	7730	7847	7964	120
15	8079	8194	8309	8422	8535	8647	8758	8868	8978	9087	112
16	9196	9304	9411	9517	9623	9728	9833	9937	°040	°142	105
17	1 0244	0346	0447	0546	0645	0743	0841	0939	1037	1134	98
18	1230	1326	1421	1516	1610	1704	1797	1890	1982	2074	94
19	1 2165	2256	2346	2436	2525	2614	2703	2791	2878	2966	89
20	3052	3139	3224	3310	3395	3480	3564	3648	3731	3814	85
21	3896	3979	4060	4142	4223	4303	4384	4463	4543	4622	81
22	1 4701	4779	4857	4935	5013	5090	5167	5244	5319	5395	77
23	5470	5545	5620	5694	5768	5842	5916	5989	6061	6134	74
24	6206	6278	6350	6421	6492	6563	6633	6703	6773	6843	71
25	1 6912	6981	7050	7119	7187	7255	7322	7390	7457	7524	68
26	7591	7657	7723	7789	7855	7920	7985	8050	8115	8179	65
27	8244	8308	8371	8435	8498	8561	8624	8686	8749	8811	63
28	1 8873	8935	8996	9057	9118	9179	9240	9300	9360	9420	61
29	9480	9540	9599	9658	9717	9776	9834	9893	9951	°009	59
30	2 0067	0124	0181	0239	0296	0352	0409	0465	0522	0578	57
31	2 0634	0689	0745	0800	0855	0910	0965	1020	1074	1128	55
32	1182	1236	1290	1344	1397	1450	1503	1556	1609	1661	53
33	1714	1766	1818	1870	1922	1973	2025	2076	2127	2178	52
34	2 2229	2280	2330	2380	2431	2481	2531	2580	2630	2679	50
35	2728	2778	2826	2875	2924	2972	3021	3069	3117	3165	49
36	3213	3260	3308	3355	3402	3449	3496	3543	3589	3636	47
37	2 3682	3728	3774	3820	3866	3911	3957	4002	4047	4093	46
38	4137	4182	4227	4271	4316	4360	4404	4448	4492	4536	44
39	4579	4623	4666	4709	4752	4795	4838	4881	4923	4966	43
40	2 5008	5050	5092	5134	5176	5218	5259	5301	5342	5383	42
41	5424	5465	5506	5546	5587	5627	5668	5708	5748	5788	40
42	5828	5867	5907	5946	5986	6025	6064	6103	6142	6181	39
43	2 6220	6258	6297	6335	6374	6412	6450	6488	6526	6564	38
44	6601	6639	6676	6714	6751	6788	6825	6862	6899	6936	37
45	6973	7009	7046	7082	7119	7155	7191	7227	7263	7299	36
46	2 7335	7371	7407	7442	7478	7513	7548	7584	7619	7654	35
47	7689	7724	7759	7794	7828	7863	7897	7932	7966	8001	35
48	8035	8069	8103	8137	8171	8205	8239	8272	8306	8340	34
49	2 8373	8407	8440	8473	8506	8540	8573	8606	8639	8672	33
50	8704	8737	8770	8802	8835	8868	8900	8932	8965	8997	33
51	9029	9061	9093	9125	9157	9189	9221	9253	9284	9316	32

(L) TABLE OF VALUES OF T_v.

V	0	1	2	3	4	5	6	7	8	9	Diff.
f-s	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	+
52	21 4.577	4.638	4.698	4.758	4.818	4.877	4.937	4.996	5.055	5.113	60
53	5.172	5.230	5.288	5.346	5.404	5.461	5.518	5.575	5.632	5.689	57
54	5.745	5.801	5.857	5.913	5.969	6.024	6.079	6.134	6.189	6.244	55
55	21 6.298	6.352	6.406	6.460	6.514	6.567	6.620	6.673	6.726	6.779	53
56	6.831	6.883	6.936	6.987	7.039	7.091	7.142	7.193	7.244	7.295	52
57	7.346	7.397	7.447	7.497	7.547	7.597	7.647	7.696	7.746	7.795	50
58	21 7.844	7.893	7.942	7.990	8.039	8.087	8.136	8.184	8.232	8.279	48
59	8.327	8.375	8.422	8.469	8.516	8.563	8.610	8.657	8.703	8.749	47
60	8.796	8.842	8.888	8.933	8.979	9.025	9.070	9.115	9.160	9.205	45
61	21 9.250	9.295	9.339	9.384	9.428	9.472	9.516	9.560	9.604	9.647	44
62	9.691	9.734	9.777	9.820	9.863	9.906	9.949	9.991	0.034	0.076	43
63	22 0.118	0.160	0.202	0.244	0.286	0.327	0.369	0.410	0.451	0.492	42
64	22 0.533	0.574	0.615	0.655	0.696	0.736	0.776	0.816	0.856	0.896	40
65	0.936	0.976	1.015	1.054	1.094	1.133	1.172	1.211	1.250	1.288	39
66	1.327	1.365	1.403	1.442	1.480	1.518	1.556	1.593	1.631	1.668	38
67	22 1.706	1.743	1.780	1.818	1.855	1.891	1.928	1.965	2.001	2.038	37
68	2.074	2.111	2.147	2.183	2.219	2.255	2.290	2.326	2.361	2.397	36
69	2.432	2.468	2.503	2.538	2.573	2.608	2.642	2.677	2.712	2.746	35
70	22 2.781	2.815	2.849	2.883	2.917	2.951	2.985	3.019	3.053	3.086	34
71	3.120	3.153	3.186	3.220	3.253	3.286	3.319	3.351	3.384	3.417	33
72	3.449	3.482	3.514	3.546	3.578	3.611	3.642	3.674	3.706	3.738	32
73	22 3.769	3.801	3.832	3.864	3.895	3.926	3.957	3.988	4.019	4.050	31
74	4.080	4.111	4.142	4.172	4.202	4.233	4.263	4.293	4.323	4.353	30
75	4.383	4.413	4.442	4.472	4.501	4.531	4.560	4.590	4.619	4.648	29
76	22 4.677	4.706	4.735	4.764	4.792	4.821	4.849	4.878	4.906	4.934	29
77	4.962	4.991	5.019	5.046	5.074	5.102	5.130	5.157	5.185	5.212	28
78	5.239	5.267	5.294	5.321	5.348	5.375	5.402	5.428	5.455	5.481	27
79	22 5.508	5.534	5.561	5.587	5.613	5.639	5.665	5.691	5.717	5.743	26
80	5.769	5.794	5.820	5.845	5.871	5.896	5.921	5.946	5.971	5.997	25
81	6.021	6.046	6.071	6.096	6.121	6.145	6.170	6.194	6.218	6.243	25
82	22 6.267	6.291	6.315	6.339	6.363	6.387	6.410	6.434	6.458	6.481	24
83	6.504	6.528	6.551	6.574	6.597	6.620	6.643	6.666	6.689	6.711	23
84	6.734	6.756	6.779	6.801	6.823	6.845	6.868	6.890	6.911	6.933	22
85	22 6.955	6.977	6.998	7.020	7.042	7.063	7.084	7.106	7.127	7.148	21
86	7.169	7.190	7.211	7.232	7.252	7.273	7.294	7.314	7.335	7.355	21
87	7.375	7.395	7.416	7.436	7.456	7.476	7.496	7.516	7.535	7.555	20
88	22 7.575	7.594	7.614	7.633	7.653	7.672	7.691	7.710	7.730	7.749	19
89	7.768	7.787	7.806	7.824	7.843	7.862	7.881	7.899	7.918	7.936	19
90	7.954	7.973	7.991	8.009	8.027	8.045	8.063	8.081	8.099	8.117	18
91	22 8.135	8.152	8.170	8.188	8.205	8.223	8.240	8.257	8.275	8.292	17
92	8.309	8.326	8.343	8.360	8.377	8.394	8.411	8.428	8.445	8.461	17
93	8.478	8.494	8.511	8.527	8.544	8.560	8.576	8.593	8.609	8.625	16
94	22 8.641	8.657	8.673	8.689	8.705	8.721	8.737	8.753	8.768	8.784	16
95	8.799	8.815	8.831	8.846	8.861	8.877	8.892	8.907	8.923	8.938	15
96	8.953	8.968	8.983	8.998	9.013	9.028	9.043	9.057	9.072	9.087	15
97	22 9.101	9.116	9.131	9.145	9.160	9.174	9.188	9.203	9.217	9.231	14
98	9.245	9.260	9.274	9.288	9.302	9.316	9.330	9.344	9.358	9.371	14
99	9.385	9.399	9.413	9.426	9.440	9.453	9.467	9.481	9.494	9.507	14

(M) TABLE OF VALUES OF S_v.

V	0	1	2	3	4	5	6	7	8	9	Diff.
f·s	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	+
52	2 9347	9379	9410	9442	9473	9504	9535	9567	9598	9629	31
53	9660	9691	9721	9752	9783	9814	9844	9875	9905	9936	31
54	9966	9997	°0027	°0057	°0088	°0118	°0148	°0178	°0208	°0238	30
55	3 0268	0298	0327	0357	0387	0416	0446	0475	0505	0534	30
56	0564	0593	0622	0651	0681	0710	0739	0768	0797	0826	29
57	0855	0883	0912	0941	0970	0998	1027	1055	1084	1112	29
58	3 1141	1169	1198	1226	1254	1283	1311	1339	1367	1395	28
59	1423	1451	1479	1507	1535	1563	1591	1619	1646	1674	28
60	1701	1730	1757	1785	1812	1840	1867	1895	1922	1949	28
61	3 1977	2004	2031	2058	2085	2112	2139	2166	2193	2220	27
62	2247	2274	2301	2328	2355	2381	2408	2435	2461	2488	27
63	2514	2541	2567	2594	2620	2646	2673	2699	2725	2751	26
64	3 2778	2804	2830	2856	2882	2908	2934	2960	2985	3011	26
65	3037	3063	3089	3114	3140	3165	3191	3217	3242	3267	26
66	3293	3318	3344	3369	3394	3419	3445	3470	3495	3520	25
67	3 3545	3570	3595	3620	3645	3670	3694	3719	3744	3769	25
68	3793	3818	3843	3867	3892	3916	3941	3965	3990	4014	25
69	4038	4063	4087	4111	4136	4160	4184	4208	4232	4256	24
70	3 4280	4305	4329	4352	4376	4400	4424	4448	4472	4496	24
71	4519	4543	4567	4590	4614	4637	4661	4684	4708	4731	24
72	4755	4778	4801	4825	4848	4871	4894	4917	4941	4964	23
73	3 4987	5010	5033	5056	5078	5101	5124	5147	5170	5192	23
74	5215	5238	5260	5283	5306	5328	5351	5373	5395	5418	23
75	5440	5463	5485	5507	5529	5552	5574	5596	5618	5640	22
76	3 5662	5684	5706	5728	5750	5772	5794	5815	5837	5859	22
77	5880	5902	5924	5945	5967	5988	6010	6031	6052	6074	22
78	6095	6116	6137	6158	6180	6201	6222	6243	6264	6285	21
79	3 6306	6326	6347	6368	6389	6410	6430	6451	6471	6492	21
80	6513	6533	6554	6574	6594	6615	6635	6655	6676	6696	20
81	6716	6736	6756	6777	6797	6817	6837	6856	6876	6896	20
82	3 6916	6936	6956	6975	6995	7014	7034	7053	7073	7092	20
83	7112	7131	7150	7170	7189	7208	7227	7246	7265	7284	19
84	7303	7322	7341	7360	7378	7397	7416	7434	7453	7472	18
85	3 7490	7509	7527	7545	7564	7582	7600	7618	7636	7654	18
86	7672	7691	7708	7726	7744	7762	7780	7798	7815	7833	18
87	7851	7868	7886	7903	7921	7938	7956	7973	7990	8008	17
88	3 8025	8042	8059	8076	8093	8110	8127	8144	8161	8178	17
89	8195	8212	8229	8245	8262	8279	8295	8312	8329	8345	17
90	8362	8378	8394	8411	8427	8443	8460	8476	8492	8508	16
91	3 8524	8540	8556	8572	8588	8604	8620	8636	8652	8668	16
92	8684	8699	8715	8731	8746	8762	8778	8793	8809	8824	16
93	8839	8855	8870	8886	8901	8916	8931	8947	8962	8977	15
94	3 8992	9007	9022	9037	9052	9067	9082	9097	9112	9126	15
95	9141	9156	9171	9185	9200	9215	9229	9244	9258	9273	15
96	9287	9302	9316	9331	9345	9359	9374	9388	9402	9416	14
97	3 9431	9445	9459	9473	9487	9501	9515	9529	9543	9557	14
98	9571	9585	9599	9612	9626	9640	9654	9667	9681	9695	14
99	9708	9722	9735	9749	9763	9776	9789	9803	9816	9830	14

(L) TABLE OF VALUES OF T_v.

V	0	1	2	3	4	5	6	7	8	9	Diff.
f-s	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	+
100	229. 5207	5340	5473	5606	5738	5869	6001	6132	6262	6392	132
101	6522	6651	6780	6908	7036	7164	7291	7418	7544	7670	127
102	7796	7921	8046	8170	8294	8417	8540	8662	8783	8904	123
103	229. 9024	9144	9262	9380	9496	9612	9727	9841	9954	°066	115
104	230. 0177	0287	0396	0504	0610	0716	0820	0923	1025	1126	105
105	1226	1325	1423	1520	1615	1710	1804	1897	1988	2079	94
106	230. 2170	2259	2347	2435	2522	2609	2694	2780	2864	2948	86
107	3031	3114	3196	3278	3359	3439	3520	3599	3678	3757	80
108	3835	3913	3990	4067	4143	4219	4295	4370	4445	4519	76
109	230. 4593	4667	4740	4813	4885	4958	5030	5101	5172	5243	72
110	5314	5384	5454	5524	5593	5662	5731	5800	5868	5936	69
111	6004	6071	6139	6206	6272	6339	6405	6471	6537	6603	66
112	230. 6668	6733	6798	6863	6928	6992	7056	7120	7184	7248	64
113	7311	7374	7437	7500	7563	7625	7688	7750	7812	7874	62
114	7936	7997	8059	8120	8181	8242	8303	8364	8424	8484	61
115	230. 8545	8605	8665	8726	8787	8847	8906	8965	9024	9083	59
116	9142	9200	9259	9317	9375	9433	9490	9548	9605	9663	58
117	9720	9777	9833	9890	9947	°003	°059	°115	°171	°227	56
118	231. 0283	0338	0394	0449	0504	0559	0614	0669	0723	0778	55
119	0832	0886	0940	0994	1048	1101	1154	1208	1261	1314	54
120	1367	1420	1473	1525	1578	1630	1682	1734	1786	1838	52
121	231. 1889	1941	1992	2043	2095	2146	2196	2247	2298	2348	51
122	2399	2449	2499	2549	2599	2649	2698	2748	2797	2847	50
123	2896	2945	2994	3043	3091	3140	3188	3237	3285	3333	49
124	231. 3381	3429	3477	3524	3572	3619	3667	3714	3761	3808	47
125	3855	3902	3948	3995	4041	4088	4134	4180	4226	4272	46
126	4318	4364	4410	4455	4501	4546	4591	4636	4681	4726	45
127	231. 4771	4816	4860	4905	4949	4993	5038	5082	5126	5170	44
128	5214	5257	5301	5345	5388	5431	5475	5518	5561	5604	43
129	5647	5690	5732	5775	5818	5860	5902	5945	5987	6029	42
130	231. 6071	6113	6155	6196	6238	6280	6321	6362	6404	6445	42
131	6486	6527	6568	6609	6650	6690	6731	6772	6812	6852	41
132	6893	6933	6973	7013	7053	7093	7133	7173	7212	7252	40
133	231. 7291	7331	7370	7410	7449	7488	7527	7566	7605	7644	39
134	7682	7721	7760	7798	7837	7875	7913	7952	7990	8028	38
135	8066	8104	8142	8179	8217	8255	8292	8330	8367	8405	38
136	231. 8442	8479	8517	8554	8591	8628	8665	8702	8738	8775	37
137	8812	8848	8885	8921	8958	8994	9030	9067	9103	9139	36
138	9175	9211	9247	9282	9318	9354	9390	9425	9461	9496	36
139	231. 9532	9567	9602	9638	9673	9708	9743	9778	9813	9848	35
140	9883	9918	9952	9987	°022	°056	°091	°125	°160	°194	35
141	232. 0228	0263	0297	0331	0365	0399	0433	0467	0501	0535	34
142	232. 0569	0602	0636	0670	0703	0737	0770	0804	0837	0870	34
143	0904	0937	0970	1003	1036	1069	1102	1135	1168	1201	33
144	1234	1267	1299	1332	1364	1397	1430	1462	1494	1527	33
145	232. 1559	1591	1624	1656	1688	1720	1752	1784	1816	1848	32
146	1880	1912	1944	1975	2007	2039	2071	2102	2134	2165	32
147	2197	2228	2260	2291	2322	2354	2385	2416	2447	2478	31

(M) TABLE OF VALUES OF S_v.

V	0	1	2	3	4	5	6	7	8	9	Diff.
f-s	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	+
100	39 842.9	856.3	869.6	882.9	896.1	909.3	922.5	935.7	948.9	961.9	13.2
101	975.0	988.1	°01.1	°14.1	°27.1	°40.0	°52.9	°65.8	°78.7	°91.5	12.9
102	40 104.3	117.1	129.8	142.5	155.2	167.8	180.4	192.9	205.4	217.8	12.6
103	40 230.1	242.4	254.6	266.8	278.8	290.8	302.7	314.5	326.2	337.8	11.9
104	349.4	360.8	372.2	383.4	394.5	405.6	416.5	427.3	438.1	448.7	11.0
105	459.2	469.6	479.9	490.0	500.1	510.1	520.0	529.8	539.5	549.2	9.9
106	40 558.7	568.2	577.6	586.9	596.2	605.4	614.5	623.6	632.6	641.6	9.2
107	650.5	659.3	668.1	676.9	685.6	704.2	702.8	711.4	719.9	728.4	8.6
108	736.8	745.2	753.6	761.9	770.2	778.4	786.6	794.8	802.9	811.0	8.2
109	40 819.0	827.1	835.0	843.0	850.9	858.9	866.7	874.6	882.4	890.2	7.9
110	897.9	905.7	913.4	921.1	928.7	936.4	944.0	951.5	959.1	966.6	7.6
111	974.2	981.6	989.1	996.6	°04.0	°11.4	°18.8	°26.2	°33.5	°40.9	7.4
112	41 048.2	055.5	062.8	070.0	077.3	084.5	091.7	099.0	106.1	113.3	7.2
113	120.5	127.6	134.8	141.9	149.0	156.1	163.2	170.2	177.3	184.4	7.1
114	191.4	198.4	205.4	212.4	219.4	226.4	233.3	240.3	247.2	254.1	7.0
115	41 261.0	267.9	274.8	281.7	288.6	295.4	302.3	309.1	315.9	322.7	6.8
116	329.5	336.3	343.1	349.8	356.6	363.3	370.0	376.7	383.4	390.1	6.7
117	396.8	403.5	410.1	416.8	423.4	430.0	436.6	443.2	449.8	456.4	6.6
118	41 462.9	469.5	476.0	482.6	489.1	495.6	502.1	508.6	515.1	521.5	6.5
119	528.0	534.4	540.9	547.3	553.7	560.1	566.5	572.9	579.2	585.6	6.4
120	591.9	598.3	604.6	610.9	617.2	623.5	629.8	636.1	642.3	648.6	6.3
121	41 654.8	661.1	667.3	673.5	679.7	685.9	692.1	698.2	704.4	710.5	6.2
122	716.7	722.8	728.9	735.0	741.1	747.2	753.3	759.4	765.4	771.5	6.1
123	777.5	783.6	789.6	795.6	801.6	807.6	813.6	819.6	825.6	831.5	6.0
124	41 837.5	843.4	849.4	855.3	861.2	867.1	873.0	878.9	884.8	890.6	5.9
125	896.5	902.3	908.2	914.0	919.8	925.6	931.5	937.3	943.0	948.8	5.8
126	954.6	960.4	966.1	971.9	977.6	983.3	989.0	994.8	°00.5	°06.2	5.7
127	42 011.8	017.5	023.2	028.9	034.5	040.2	045.8	051.4	057.0	062.7	5.6
128	068.3	073.9	079.5	085.0	090.6	096.2	101.8	107.3	112.9	118.4	5.6
129	123.9	129.4	135.0	140.5	146.0	151.5	157.0	162.4	167.9	173.4	5.5
130	42 178.8	184.3	189.7	195.1	200.6	206.0	211.4	216.8	222.2	227.6	5.4
131	233.0	238.4	243.7	249.1	254.5	259.8	265.1	270.5	275.8	281.1	5.3
132	286.4	291.8	297.1	302.4	307.6	312.9	318.2	323.5	328.7	334.0	5.3
133	42 339.2	344.5	349.7	355.0	360.2	365.4	370.6	375.8	381.0	386.2	5.2
134	391.4	396.6	401.8	406.9	412.1	417.3	422.4	427.6	432.7	437.8	5.2
135	443.0	448.1	453.2	458.3	463.4	468.5	473.6	478.7	483.8	488.9	5.1
136	42 493.9	499.0	504.1	509.1	514.2	519.2	524.3	529.3	534.3	539.4	5.0
137	544.4	549.4	554.4	559.4	564.4	569.4	574.4	579.4	584.3	589.3	5.0
138	594.3	599.2	604.2	609.1	614.1	619.0	624.0	628.9	633.8	638.8	4.9
139	42 643.7	648.6	653.5	658.4	663.3	668.2	673.1	678.0	682.9	687.8	4.9
140	692.6	697.5	702.4	707.2	712.1	717.0	721.8	726.7	731.5	736.3	4.9
141	741.2	746.0	750.8	755.7	760.5	765.3	770.1	774.9	779.7	784.5	4.8
142	42 789.3	794.1	798.9	803.7	808.5	813.2	818.0	822.8	827.5	832.3	4.8
143	837.1	841.8	846.6	851.3	856.0	860.8	865.5	870.2	875.0	879.7	4.7
144	884.4	889.1	893.8	898.6	903.3	908.0	912.7	917.4	922.1	926.7	4.7
145	42 931.4	936.1	940.8	945.5	950.1	954.8	959.5	964.1	968.8	973.5	4.7
146	978.1	982.8	987.4	992.1	996.7	°01.3	°06.0	°10.6	°15.2	°19.9	4.6
147	43 024.5	029.1	033.7	038.4	043.0	047.6	052.2	056.8	061.4	066.0	4.6

(L) TABLE OF VALUES OF T_v.

V	0	1	2	3	4	5	6	7	8	9	Diff.
f·s	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	+
148	232. 2509	2540	2571	2602	2633	2664	2695	2726	2757	2787	31
149	2818	2849	2879	2910	2940	2971	3001	3032	3062	3093	30
150	3123	3153	3183	3214	3244	3274	3304	3334	3364	3394	30
151	232. 3424	3454	3484	3514	3543	3573	3603	3633	3662	3692	30
152	3722	3751	3781	3810	3840	3869	3899	3928	3958	3987	29
153	4016	4046	4075	4104	4133	4162	4192	4221	4250	4279	29
154	232. 4308	4337	4366	4395	4424	4453	4481	4510	4539	4568	29
155	4597	4625	4654	4683	4711	4740	4768	4797	4825	4854	29
156	4882	4911	4939	4967	4996	5024	5052	5080	5108	5137	28
157	232. 5165	5193	5221	5249	5277	5305	5333	5361	5389	5416	28
158	5444	5472	5500	5528	5555	5583	5611	5638	5666	5693	28
159	5721	5748	5776	5803	5831	5858	5885	5913	5940	5967	27
160	232. 5994	6022	6049	6076	6103	6130	6157	6184	6211	6238	27
161	6265	6292	6319	6346	6373	6400	6426	6453	6480	6506	27
162	6533	6560	6586	6613	6640	6666	6693	6719	6745	6772	26
163	232. 6798	6825	6851	6877	6903	6930	6956	6982	7008	7034	26
164	7061	7087	7113	7139	7165	7191	7217	7243	7268	7294	26
165	7320	7346	7372	7398	7423	7449	7475	7500	7526	7552	26
166	232. 7577	7603	7628	7654	7679	7705	7730	7756	7781	7806	25
167	7832	7857	7882	7908	7933	7958	7983	8008	8034	8059	25
168	8084	8109	8134	8159	8184	8209	8234	8258	8283	8308	25
169	232. 8333	8358	8383	8407	8432	8457	8481	8506	8531	8555	25
170	8580	8604	8629	8653	8678	8702	8726	8751	8775	8799	24
171	8824	8848	8872	8896	8921	8945	8969	8993	9017	9041	24
172	232. 9065	9089	9113	9137	9161	9185	9209	9233	9257	9281	24
173	9304	9328	9352	9376	9399	9423	9447	9470	9494	9518	24
174	9541	9565	9588	9612	9635	9659	9682	9705	9729	9752	23
175	232. 9776	9799	9822	9845	9869	9892	9916	9938	9961	9985	23
176	233. 0008	0031	0054	0077	0100	0123	0146	0169	0192	0215	23
177	0237	0260	0283	0306	0329	0351	0374	0397	0420	0442	23
178	233. 0465	0488	0510	0533	0555	0578	0600	0623	0645	0668	23
179	0690	0713	0735	0757	0780	0802	0824	0847	0869	0891	22
180	0913	0935	0958	0980	1002	1024	1046	1068	1090	1112	22
181	233. 1134	1156	1178	1200	1222	1244	1266	1287	1309	1331	22
182	1353	1375	1396	1418	1440	1461	1483	1505	1526	1548	22
183	1569	1591	1613	1634	1656	1677	1698	1720	1741	1763	21
184	233. 1784	1805	1827	1848	1869	1891	1912	1933	1954	1975	21
185	1997	2018	2039	2060	2081	2102	2123	2144	2165	2186	21
186	2207	2228	2249	2270	2291	2312	2333	2353	2374	2395	21
187	233. 2416	2437	2457	2478	2499	2520	2540	2561	2582	2602	21
188	2623	2643	2664	2685	2705	2726	2746	2767	2787	2808	21
189	2828	2848	2869	2889	2909	2930	2950	2970	2991	3011	20
190	233. 3031	3051	3072	3092	3112	3132	3152	3172	3192	3212	20
191	3233	3253	3273	3293	3313	3333	3353	3372	3392	3412	20
192	3432	3452	3472	3492	3511	3531	3551	3571	3590	3610	20
193	233. 3630	3649	3669	3689	3708	3728	3747	3767	3786	3806	20
194	3825	3845	3864	3884	3903	3922	3942	3961	3980	4000	19
195	4019	4038	4057	4077	4096	4115	4134	4153	4172	4192	19

(M) TABLE OF VALUES OF S_v.

V	0	1	2	3	4	5	6	7	8	9	Diff.
f-s	feet.	feet.	feet	feet.	feet.	feet.	feet.	feet.	feet.	feet.	+
148	43 070.6	075.2	079.8	084.4	089.0	093.5	098.1	102.7	107.3	111.8	4.6
149	116.4	121.0	125.6	130.1	134.7	139.2	143.8	148.3	152.9	157.4	4.6
150	162.0	166.5	171.0	175.6	180.1	184.6	189.2	193.7	198.2	202.7	4.5
151	43 207.2	211.8	216.3	220.8	225.3	229.8	234.3	238.8	243.3	247.8	4.5
152	252.3	256.8	261.3	265.8	270.3	274.8	279.3	283.8	288.3	292.8	4.5
153	297.2	301.7	306.2	310.6	315.1	319.6	324.1	328.5	333.0	337.5	4.5
154	43 342.0	346.4	350.9	355.3	359.8	364.3	368.7	373.2	377.6	382.1	4.5
155	386.5	391.0	395.4	399.9	404.3	408.7	413.2	417.6	422.0	426.5	4.4
156	430.9	435.3	439.8	444.2	448.6	453.0	457.4	461.9	466.3	470.7	4.4
157	43 475.1	479.5	483.9	488.3	492.7	497.1	501.5	505.9	510.3	514.7	4.4
158	519.1	523.5	527.9	532.3	536.7	541.1	545.4	549.8	554.2	558.6	4.4
159	563.0	567.3	571.7	576.1	580.4	584.8	589.1	593.5	597.9	602.2	4.4
160	43 606.6	610.9	615.3	619.6	624.0	628.3	632.6	637.0	641.3	645.7	4.3
161	650.0	654.3	658.7	663.0	667.3	671.6	676.0	680.3	684.6	688.9	4.3
162	693.3	697.6	701.9	706.2	710.5	714.8	719.1	723.4	727.7	732.0	4.3
163	43 736.3	740.6	744.9	749.2	753.5	757.8	762.1	766.4	770.6	774.9	4.3
164	779.2	783.5	787.8	792.0	796.3	800.6	804.9	809.1	813.4	817.6	4.3
165	821.9	826.2	830.4	834.7	838.9	843.2	847.4	851.7	855.9	860.2	4.3
166	43 864.4	868.7	872.9	877.2	881.4	885.6	889.9	894.1	898.3	902.5	4.2
167	906.8	911.0	915.2	919.5	923.7	927.9	932.1	936.3	940.5	944.7	4.2
168	949.0	953.2	957.4	961.6	965.8	970.0	974.2	978.4	982.6	986.7	4.2
169	43 990.9	995.1	999.3	°03.5	°07.7	°12.0	°16.0	°20.2	°24.4	°28.6	4.2
170	44 032.7	036.9	041.1	045.2	049.4	053.6	057.7	061.9	066.0	070.2	4.2
171	074.3	078.5	082.6	086.8	090.9	095.1	099.2	103.3	107.5	111.6	4.1
172	44 115.7	119.9	124.0	128.1	132.3	136.4	140.5	144.6	148.7	152.9	4.1
173	157.0	161.1	165.2	169.3	173.4	177.5	181.6	185.7	189.8	193.9	4.1
174	198.0	202.1	206.2	210.3	214.4	218.5	222.6	226.7	230.8	234.8	4.1
175	44 238.9	243.0	247.1	251.2	255.3	259.3	263.4	267.5	271.5	275.6	4.1
176	279.6	283.7	287.8	291.8	295.9	300.0	304.0	308.0	312.1	316.1	4.1
177	320.2	324.2	328.3	332.3	336.4	340.4	344.4	348.5	352.5	356.5	4.0
178	44 360.5	364.6	368.6	372.6	376.6	380.7	384.7	388.7	392.7	396.7	4.0
179	400.7	404.7	408.8	412.8	416.8	420.8	424.8	428.8	432.8	436.8	4.0
180	440.8	444.7	448.7	452.7	456.7	460.7	464.7	468.7	472.6	476.6	4.0
181	44 480.6	484.6	488.5	492.5	496.5	500.5	504.4	508.4	512.4	516.3	4.0
182	520.3	524.2	528.2	532.2	536.1	540.1	544.0	548.0	551.9	555.9	4.0
183	559.8	563.7	567.7	571.6	575.6	579.5	583.4	587.4	591.3	595.2	3.9
184	44 599.2	603.1	607.0	610.9	614.9	618.8	622.7	626.6	630.5	634.4	3.9
185	638.4	642.3	646.2	650.1	654.0	657.9	661.8	665.7	669.6	673.5	3.9
186	677.4	681.3	685.2	689.1	693.0	696.9	700.8	704.6	708.5	712.4	3.9
187	44 716.3	720.2	724.1	727.9	731.8	735.7	739.6	743.4	747.3	751.2	3.9
188	755.0	758.9	762.8	766.7	770.5	774.4	778.2	782.1	786.0	789.8	3.9
189	793.7	797.5	801.4	805.2	809.1	812.9	816.8	820.6	824.5	828.3	3.8
190	44 832.2	836.0	839.8	843.7	847.5	851.4	855.2	859.0	862.8	866.7	3.8
191	870.5	874.3	878.1	882.0	885.8	889.6	893.4	897.3	901.1	904.9	3.8
192	908.7	912.5	916.3	920.1	923.9	927.7	931.5	935.3	939.1	942.9	3.8
193	44 946.7	950.5	954.3	958.1	961.9	965.7	969.4	973.2	977.0	980.7	3.8
194	984.5	988.3	992.1	995.8	999.6	°03.4	°07.1	°10.9	°14.7	°18.4	3.8
195	45 022.2	025.9	029.7	033.4	037.2	040.9	044.7	048.4	052.1	055.9	3.7

(L) TABLE OF VALUES OF T_v.

V	0	1	2	3	4	5	6	7	8	9	Diff.
f·s	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	+
196	233. 4211	4230	4249	4268	4287	4306	4325	4344	4362	4381	19
197	4400	4419	4438	4457	4476	4494	4513	4532	4550	4569	19
198	4588	4606	4625	4644	4662	4681	4699	4718	4736	4755	19
199	233. 4773	4791	4810	4828	4846	4865	4883	4901	4920	4938	18
200	4956	4974	4992	5010	5028	5047	5065	5083	5101	5119	18
201	5137	5155	5172	5190	5208	5226	5244	5262	5280	5297	18
202	233. 5315	5333	5351	5368	5386	5404	5421	5439	5456	5474	18
203	5492	5509	5527	5544	5561	5579	5596	5614	5631	5648	17
204	5666	5683	5700	5717	5735	5752	5769	5786	5803	5820	17
205	233. 5837	5854	5871	5888	5905	5922	5939	5956	5973	5990	17
206	6007	6024	6040	6057	6074	6091	6107	6124	6141	6157	17
207	6174	6191	6207	6224	6240	6257	6273	6290	6306	6323	16
208	233. 6339	6355	6372	6388	6404	6420	6437	6453	6469	6485	16
209	6502	6518	6534	6550	6566	6582	6598	6614	6630	6646	16
210	6662	6678	6694	6710	6726	6741	2757	6773	6789	6805	16
211	233. 6820	6836	6852	6867	6883	6899	6914	6930	6946	6961	16
212	6977	6992	7008	7023	7039	7054	7070	7085	7100	7116	15
213	7131	7146	7162	7177	7192	7207	7223	7238	7253	7268	15
214	233. 7283	7298	7313	7329	7344	7359	7374	7389	7404	7419	15
215	7434	7448	7463	7478	7493	7508	7523	7538	7552	7567	15
216	7582	7597	7612	7626	7641	7656	7670	7685	7700	7714	15
217	233. 7729	7743	7758	7772	7787	7801	7816	7830	7845	7859	14
218	7874	7888	7902	7917	7931	7945	7960	7974	7988	8002	14
219	8016	8031	8045	8059	8073	8087	8101	8115	8129	8144	14
220	233. 8158	8172	8186	8200	8214	8227	8241	8255	8269	8283	14
221	8297	8311	8325	8338	8352	8366	8380	8394	8407	8421	14
222	8435	8448	8462	8476	8489	8503	8517	8530	8544	8557	14
223	233. 8571	8584	8598	8611	8625	8638	8651	8665	8678	8692	13
224	8705	8718	8732	8745	8758	8772	8785	8798	8811	8824	13
225	8838	8851	8864	8877	8890	8903	8916	8930	8943	8956	13
226	233. 8969	8982	8995	9008	9021	9034	9047	9059	9072	9085	13
227	9098	9111	9124	9137	9150	9162	9175	9188	9201	9213	13
228	9226	9239	9252	9264	9277	9290	9303	9315	9328	9341	13
229	233. 9353	9366	9378	9391	9404	9416	9429	9441	9454	9467	13
230	9479	9492	9504	9517	9529	9542	9554	9567	9579	9592	13
231	9604	9617	9629	9642	9654	9667	9679	9692	9704	9716	12
232	233. 9729	9741	9754	9766	9779	9791	9803	9816	9828	9841	12
233	9853	9866	9878	9890	9903	9915	9927	9940	9952	9965	12
234	9977	9989	0002	0014	0026	0039	0051	0063	0076	0088	12
235	234. 0100	0113	0125	0137	0150	0162	0174	0186	0199	0211	12
236	0223	0236	0248	0260	0272	0284	0297	0309	0321	0334	12
337	0346	0358	0370	0383	0395	0407	0419	0431	0444	0456	12
238	234. 0468	0480	0492	0505	0517	0529	0541	0553	0566	0578	12
239	0590	0602	0614	0626	0639	0651	0663	0675	0687	0699	12
240	0711	0724	0736	0748	0760	0772	0784	0796	0809	0821	12
241	234. 0833	0845	0857	0869	0881	0893	0905	0917	0930	0942	12
242	0954	0966	0978	0990	1002	1014	1026	1038	1050	1062	12
243	1074	1087	1099	1111	1123	1135	1147	1159	1171	1183	12

(M) TABLE OF VALUES OF S_v.

V	0	1	2	3	4	5	6	7	8	9	Diff.
f-s	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	+
196	45 059.6	063.4	067.1	070.8	074.6	078.3	082.0	085.7	089.4	093.1	3.7
197	096.9	100.6	104.3	108.0	111.7	115.4	119.1	122.8	126.5	130.2	3.7
198	133.9	137.5	141.2	144.9	148.6	152.3	156.0	159.6	163.3	166.9	3.7
199	45 170.6	174.3	177.9	181.6	185.2	188.9	192.5	196.2	199.8	203.4	3.6
200	207.1	210.7	214.3	218.0	221.6	225.2	228.8	232.5	236.1	239.7	3.6
201	243.3	246.9	250.5	254.1	257.7	261.3	264.9	268.5	272.1	275.7	3.6
202	45 279.2	282.8	286.4	290.0	293.6	297.2	300.7	304.3	307.8	311.4	3.6
203	314.9	318.5	322.0	325.6	329.1	332.7	336.2	339.7	343.3	346.8	3.5
204	350.3	353.8	357.3	360.9	364.4	367.9	371.4	374.9	378.4	381.9	3.5
205	45 385.4	388.9	392.4	395.9	399.4	402.9	406.3	409.8	413.3	416.7	3.5
206	420.2	423.7	427.1	430.6	434.1	437.5	441.0	444.4	447.8	451.3	3.5
207	454.7	458.1	461.6	465.0	468.4	471.9	475.3	478.7	482.1	485.5	3.4
208	45 488.9	492.3	495.7	499.1	502.5	505.9	509.3	512.7	516.1	519.4	3.4
209	522.8	526.2	529.6	532.9	536.3	539.7	543.0	546.4	549.7	553.1	3.4
210	556.4	559.8	563.1	566.4	569.8	573.1	576.5	579.8	583.1	586.4	3.3
211	45 589.7	593.0	596.4	599.7	603.0	606.3	609.6	612.9	616.2	619.5	3.3
212	622.8	626.1	629.3	632.6	635.9	639.2	642.5	645.7	649.0	652.3	3.3
213	655.5	658.8	662.0	665.3	668.6	671.8	675.1	678.3	681.5	684.8	3.2
214	45 688.0	691.2	694.5	697.7	700.9	704.2	707.4	710.6	713.8	717.0	3.2
215	720.2	723.4	726.6	729.9	733.1	736.3	739.5	742.6	745.8	749.0	3.2
216	752.2	755.4	758.6	761.8	764.9	768.1	771.3	774.4	777.6	780.8	3.2
217	45 783.9	787.1	790.2	793.4	796.6	799.7	802.9	806.0	809.1	812.2	3.1
218	815.4	818.5	821.6	824.8	827.9	831.0	834.1	837.3	840.4	843.5	3.1
219	846.6	849.7	852.8	855.9	859.0	862.1	865.2	868.3	871.4	874.4	3.1
220	45 877.5	880.6	883.7	886.8	889.9	893.0	896.0	899.1	902.1	905.2	3.1
221	908.3	911.3	914.4	917.4	920.5	923.6	926.6	929.6	932.7	935.7	3.0
222	938.7	941.8	944.8	947.8	950.9	953.9	956.9	959.9	963.0	966.0	3.0
223	45 969.0	972.0	975.0	978.0	981.0	984.0	987.0	990.0	993.0	996.0	3.0
224	999.0	°002.0	°004.9	°007.9	°010.9	°013.9	°016.9	°019.8	°022.8	°025.8	3.0
225	46 028.7	031.7	034.6	037.6	040.6	043.6	046.5	049.5	052.4	055.3	3.0
226	46 058.3	061.2	064.1	067.1	070.0	072.9	075.9	078.8	081.7	084.7	2.9
227	087.6	090.5	093.4	096.3	099.3	102.2	105.1	108.0	110.9	113.8	2.9
228	116.7	119.6	122.5	125.4	128.3	131.2	134.1	137.0	139.9	142.8	2.9
229	46 145.7	148.6	151.5	154.4	157.3	160.2	163.1	166.0	168.8	171.7	2.9
230	174.6	177.5	180.4	183.3	186.2	189.1	191.9	194.8	197.7	200.6	2.9
231	203.5	206.4	209.3	212.1	215.0	217.9	220.8	223.7	226.6	229.5	2.9
232	46 232.3	235.2	238.1	241.0	243.9	246.8	249.7	252.6	255.4	258.3	2.9
233	261.2	264.1	267.0	269.9	272.8	275.7	278.6	281.5	284.3	287.2	2.9
234	290.1	293.0	295.9	298.8	301.7	304.6	307.5	310.4	313.3	316.2	2.9
235	46 319.0	322.0	324.9	327.7	330.6	333.5	336.4	339.3	342.2	345.1	2.9
236	348.0	350.9	353.8	356.7	359.6	362.5	365.4	368.3	371.2	374.1	2.9
237	377.0	379.9	382.8	385.7	388.6	391.5	394.4	397.3	400.2	403.1	2.9
238	46 406.0	408.9	411.8	414.8	417.7	420.6	423.5	426.4	429.3	432.2	2.9
239	435.1	438.0	440.9	443.8	446.8	449.7	452.6	455.5	458.4	461.3	2.9
240	464.2	467.1	470.1	473.0	475.9	478.8	481.7	484.6	487.6	490.5	2.9
241	46 493.4	496.3	499.2	502.2	505.1	508.0	510.9	513.8	516.8	519.7	2.9
242	522.6	525.6	528.5	531.4	534.3	537.3	540.2	543.1	546.1	549.0	2.9
243	551.9	554.9	557.8	560.7	563.7	566.6	569.5	572.5	575.4	578.3	2.9

(L) TABLE OF VALUES OF T_v.

V	0	1	2	3	4	5	6	7	8	9	Diff.
f-s	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	+
244	234. 1195	1207	1219	1231	1243	1255	1267	1279	1291	1303	12
245	1315	1327	1339	1351	1363	1375	1387	1399	1411	1423	12
246	1435	1447	1459	1471	1483	1495	1506	1518	1530	1542	12
247	234. 1554	1566	1578	1590	1602	1614	1626	1638	1649	1661	12
248	1673	1685	1697	1709	1721	1733	1744	1756	1768	1780	12
249	1792	1804	1815	1827	1839	1851	1863	1874	1886	1898	12
250	234. 1910	1922	1933	1945	1957	1969	1980	1992	2004	2015	12
251	2027	2039	2051	2062	2074	2086	2097	2109	2121	2132	12
252	2144	2156	2167	2179	2190	2202	2214	2225	2237	2248	12
253	234. 2260	2272	2283	2295	2306	2318	2329	2341	2352	2364	12
254	2375	2387	2398	2410	2421	2433	2444	2455	2467	2478	11
255	2490	2501	2513	2524	2535	2547	2558	2569	2581	2592	11
256	234. 2603	2615	2626	2637	2648	2660	2671	2682	2693	2705	11
257	2716	2727	2738	2749	2760	2772	2783	2794	2805	2816	11
258	2827	2838	2849	2860	2871	2882	2893	2904	2915	2926	11
259	234. 2937	2948	2959	2970	2981	2992	3003	3014	3025	3036	11
260	3046	3057	3068	3079	3090	3101	3111	3122	3133	3144	11
261	3154	3165	3176	3187	3197	3208	3219	3229	3240	3250	11
262	234. 3261	3272	3282	3293	3303	3314	3325	3335	3346	3356	11
263	3367	3377	3388	3398	3409	3419	3429	3440	3450	3461	10
264	3471	3482	3492	3502	3513	3523	3533	3544	3554	3564	10
265	334. 3574	3585	3595	3605	3615	3626	3636	3646	3656	3667	10
266	3677	3687	3697	3707	3717	3728	3738	3748	3758	3768	10
267	3778	3788	3798	3808	3818	3828	3838	3848	3858	3868	10
268	234. 3878	3888	3898	3908	3918	3928	3938	3948	3958	3968	10
269	3977	3987	3997	4007	4017	4027	4036	4046	4056	4066	10
270	4075	4085	4095	4105	4114	4124	4134	4143	4153	4163	10
271	234. 4172	4182	4192	4201	4211	4220	4230	4240	4249	4259	10
272	4268	4278	4287	4297	4307	4316	4326	4335	4344	4354	10
273	4363	4373	4382	4392	4401	4411	4420	4429	4439	4448	9
274	234. 4457	4467	4476	4485	4495	4504	4513	4523	4532	4541	9
275	4551	4560	4569	4578	4587	4597	4606	4615	4624	4633	9
276	4643	4652	4661	4670	4679	4688	4697	4706	4715	4725	9
277	234. 4734	4743	4752	4761	4770	4779	4788	4797	4806	4815	9
278	4824	4833	4842	4850	4859	4868	4877	4886	4895	4904	9
279	4913	4922	4930	4939	4948	4957	4966	4975	4983	4992	9
280	234. 5001	5010	5018	5027	5036	5045	5053	5062	5071	5080	9
281	5088	5097	5105	5114	5123	5131	5140	5148	5157	5166	9
282	5174	5183	5191	5200	5208	5217	5226	5234	5243	5251	9
283	234. 5260	5268	5277	5285	5293	5302	5310	5319	5327	5336	8
284	5344	5352	5361	5369	5378	5386	5394	5403	5411	5419	8
285	5427	5436	5444	5452	5461	5469	5477	5485	5494	5502	8
286	234. 5510	5518	5527	5535	5543	5551	5559	5567	5576	5584	8
287	5592	5600	5608	5616	5624	5632	5641	5648	5657	5665	8
288	5673	5681	5689	5697	5705	5713	5721	5729	5737	5745	8
289	234. 5753	5761	5769	5777	5785	5793	5800	5808	5816	5824	8
290	5832	5840	5848	5856	5864	5871	5879	5887	5895	5903	8
291	5910	5918	5926	5934	5942	5949	5957	5965	5973	5980	8

(M) TABLE OF VALUES OF S_v.

V	0	1	2	3	4	5	6	7	8	9	Diff.
f-s	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	+
244	46 581.3	584.2	587.2	590.1	593.0	596.0	598.9	601.8	604.8	607.7	2.9
245	610.6	613.6	616.5	619.5	622.4	625.3	628.3	631.2	634.2	637.1	2.9
246	640.1	643.0	645.9	648.9	651.8	654.8	657.7	660.6	663.6	666.5	2.9
247	46 669.5	672.4	675.4	678.3	681.3	684.2	687.2	690.1	693.0	696.0	2.9
248	698.9	701.9	704.8	707.8	710.7	713.7	716.6	719.6	722.5	725.5	2.9
249	728.4	731.3	734.3	737.2	740.2	743.1	746.1	749.0	752.0	754.9	2.9
250	46 757.8	760.7	763.7	766.7	769.6	772.6	775.5	778.4	781.4	784.3	2.9
251	787.3	790.2	793.1	796.1	799.0	802.0	804.9	807.8	810.8	813.7	2.9
252	816.6	819.6	822.5	825.4	828.4	831.3	834.2	837.1	840.1	843.0	2.9
253	46 845.9	848.8	851.8	854.7	857.6	860.5	863.5	866.4	869.3	872.2	2.9
254	875.1	878.1	881.0	883.9	886.8	889.7	892.6	895.6	898.5	901.4	2.9
255	904.3	907.2	910.1	913.0	915.9	918.8	921.7	924.6	927.5	930.4	2.9
256	46 933.3	936.2	939.1	942.0	944.9	947.8	950.6	953.5	956.4	959.3	2.9
257	962.2	965.0	967.9	970.8	973.7	976.5	979.4	982.3	985.1	988.0	2.9
258	990.9	993.7	996.6	999.4	°02.3	°05.1	°08.0	°10.8	°13.7	°16.5	2.9
259	47 019.4	022.2	025.0	027.9	030.7	033.5	036.4	039.2	042.0	044.8	2.8
260	047.7	050.5	053.3	056.1	058.9	061.7	064.5	067.4	070.2	073.0	2.8
261	075.8	078.6	081.4	084.2	087.0	089.7	092.5	095.3	098.1	100.9	2.8
262	47 103.7	106.5	109.2	112.0	114.8	117.6	120.3	123.1	125.9	128.6	2.8
263	131.4	134.2	136.9	139.7	142.4	145.2	147.9	150.7	153.4	156.2	2.8
264	158.9	161.7	164.4	167.1	169.9	172.6	175.4	178.1	180.8	183.5	2.7
265	47 186.3	189.0	191.7	194.4	197.1	199.9	202.6	205.3	208.0	210.7	2.7
266	213.4	216.1	218.8	221.5	224.2	226.9	229.6	232.3	235.0	237.7	2.7
267	240.4	243.1	245.8	248.5	251.2	253.8	256.5	259.2	261.9	264.5	2.7
268	47 267.2	269.9	272.5	275.2	277.9	280.5	283.2	285.9	288.5	291.2	2.7
269	293.8	296.5	299.1	301.8	304.4	307.1	309.7	312.3	315.0	317.6	2.6
270	320.2	322.9	325.5	328.1	330.8	333.4	336.0	338.6	341.2	343.9	2.6
271	47 346.5	349.1	351.7	354.3	356.9	359.5	362.1	364.7	367.3	369.9	2.6
272	372.5	375.1	377.7	380.3	382.9	385.5	388.1	390.7	393.3	395.8	2.6
273	398.4	401.0	403.6	406.2	408.7	411.3	413.9	416.4	419.0	421.6	2.6
274	47 424.1	426.7	429.3	431.8	434.4	436.9	439.5	442.0	444.6	447.1	2.6
275	449.7	452.2	454.8	457.3	459.8	462.4	464.9	467.4	470.0	472.5	2.5
276	475.0	477.5	480.1	482.6	485.1	487.6	490.1	492.7	495.2	497.7	2.5
277	47 500.2	502.7	505.2	507.7	510.2	512.7	515.2	517.7	520.2	522.7	2.5
278	525.2	527.7	530.1	532.6	535.1	537.6	540.1	542.6	545.0	547.5	2.5
279	550.0	552.4	554.9	557.4	559.9	562.3	564.8	567.2	569.7	572.2	2.5
280	47 574.6	577.1	579.5	582.0	584.4	586.8	589.3	591.7	594.2	596.6	2.4
281	599.0	601.5	603.9	606.4	608.8	611.2	613.6	616.1	618.5	620.9	2.4
282	623.3	625.7	628.2	630.6	633.0	635.4	637.8	640.2	642.6	645.0	2.4
283	47 647.4	649.8	652.2	654.6	657.0	659.4	661.8	664.2	666.6	669.0	2.4
284	671.3	673.7	676.1	678.5	680.9	683.3	685.6	688.0	690.4	692.7	2.4
285	695.1	697.5	699.8	702.2	704.6	706.9	709.3	711.6	714.0	716.4	2.4
286	47 718.7	721.1	723.4	725.8	728.1	730.4	732.8	735.1	737.5	739.8	2.3
287	742.1	744.5	746.8	749.1	751.5	753.8	756.1	758.4	760.8	763.1	2.3
288	765.4	767.7	770.0	772.4	774.7	777.0	779.3	781.6	783.9	786.2	2.3
289	47 788.5	790.8	793.1	795.4	797.7	800.0	802.3	804.6	806.9	809.2	2.3
290	811.5	813.7	816.0	818.3	820.6	822.9	825.2	827.4	829.7	832.0	2.3
291	834.3	836.5	838.8	841.1	843.3	845.6	847.9	850.1	852.4		

(N) φ	Log $(P_{\varphi}-P_{\varphi-1})$	Log $(P_{\varphi}-P_{\varphi-2})$	Log $(P_{\varphi}-P_{\varphi-4})$	φ	Log $(P_{\varphi}-P_{\varphi-1})$	Log $(P_{\varphi}-P_{\varphi-2})$	Log $(P_{\varphi}-P_{\varphi-4})$
°				°			
1	8. 719 09			31	8. 977 78	9. 270 14	9. 554 68
2	8. 719 61	9. 020 38		32	8. 996 00	9. 288 01	9. 571 88
3	8. 720 67	9. 021 17		33	9. 014 95	9. 306 61	9. 589 78
4	8. 722 26	9. 022 50	9. 322 47	34	9. 034 64	9. 325 94	9. 608 42
5	8. 724 39	9. 024 36	9. 323 80	35	9. 055 10	9. 346 02	9. 627 80
6	8. 727 04	9. 026 75	9. 325 66	36	9. 076 33	9. 366 87	9. 647 92
7	8. 730 22	9. 029 66	9. 328 05	37	9. 098 37	9. 388 52	9. 668 81
8	8. 733 94	9. 033 12	9. 330 97	38	9. 121 22	9. 410 97	9. 690 52
9	8. 738 21	9. 037 11	9. 334 43	39	9. 144 91	9. 434 26	9. 713 02
10	8. 743 02	9. 041 65	9. 338 44	40	9. 169 47	9. 458 40	9. 736 37
11	8. 748 36	9. 046 73	9. 342 98	41	9. 194 92	9. 483 41	9. 760 56
12	8. 754 26	9. 052 35	9. 348 06	42	9. 221 28	9. 509 33	9. 785 64
13	8. 760 70	9. 058 52	9. 353 69	43	9. 248 59	9. 536 18	9. 811 63
14	8. 767 70	9. 065 24	9. 359 87	44	9. 276 87	9. 563 99	9. 838 55
15	8. 775 27	9. 072 53	9. 366 61	45	9. 306 16	9. 592 79	9. 866 44
16	8. 783 38	9. 080 37	9. 373 91	46	9. 336 49	9. 622 62	9. 895 32
17	8. 792 08	9. 088 78	9. 381 76	47	9. 367 90	9. 653 51	9. 925 24
18	8. 801 36	9. 097 77	9. 390 19	48	9. 400 42	9. 685 49	9. 956 22
19	8. 811 21	9. 107 34	9. 399 19	49	9. 434 10	9. 718 62	9. 988 31
20	8. 821 64	9. 117 49	9. 408 77	50	9. 469 00	9. 752 93	0. 021 55
21	8. 832 69	9. 128 23	9. 418 94	51	9. 505 14	9. 788 47	0. 055 98
22	8. 844 33	9. 139 58	9. 429 70	52	9. 542 60	9. 825 30	0. 091 65
23	8. 856 58	9. 151 53	9. 441 06	53	9. 581 42	9. 863 47	0. 128 61
24	8. 869 45	9. 164 09	9. 453 04	54	9. 621 67	9. 903 04	0. 166 94
25	8. 882 95	9. 177 28	9. 465 62	55	9. 663 42	9. 944 08	0. 206 67
26	8. 897 09	9. 191 11	9. 478 84	56	9. 706 74	9. 986 65	0. 247 89
27	8. 911 88	9. 205 58	9. 492 69	57	9. 751 71	0. 030 84	0. 290 65
28	8. 927 33	9. 220 71	9. 507 19	58	9. 798 43	0. 076 73	0. 335 05
29	8. 943 46	9. 236 50	9. 522 34	59	9. 846 97	0. 124 41	0. 381 17
30	8. 960 27	9. 252 98	9. 538 17	60	9. 897 46	0. 173 98	0. 429 10

(O) TABLE OF VALUES OF $\cos^3\varphi$.

φ °		φ °		φ °		φ °		φ °	
1	9. 999 80	13	9. 966 17	25	9. 871 83	37	9. 707 05	49	9. 450 83
2	9. 999 21	14	9. 960 71	26	9. 860 98	38	9. 689 60	50	9. 424 20
3	9. 998 21	15	9. 954 83	27	9. 849 64	39	9. 671 51	51	9. 396 62
4	9. 996 82	16	9. 948 52	28	9. 837 80	40	9. 652 76	52	9. 368 03
5	9. 995 03	17	9. 941 79	29	9. 825 46	41	9. 633 34	53	9. 338 39
6	9. 992 84	18	9. 934 62	30	9. 812 59	42	9. 613 22	54	9. 307 66
7	9. 990 25	19	9. 927 01	31	9. 799 20	43	9. 592 38	55	9. 275 77
8	9. 987 26	20	9. 918 96	32	9. 785 26	44	9. 570 80	56	9. 242 69
9	9. 983 86	21	0. 910 46	33	9. 770 77	45	9. 548 46	57	9. 208 33
10	9. 980 05	22	9. 901 50	34	9. 755 72	46	9. 525 31	58	9. 172 63
11	9. 975 84	23	9. 892 08	35	9. 740 09	47	9. 501 35	59	9. 135 52
12	9. 971 21	24	9. 882 19	36	9. 723 87	48	9. 476 53	60	9. 096 91

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142
152